Riffing on Strings

Creative Writing Inspired by String Theory

Edited by Sean Miller & Shveta Verma

Science/Literature

Riffing ON STRINGS is a unique collection of creative writing that explores the cosmic and cultural resonances of string theory. Inside you'll find thought-provoking essays, short stories, poems, and a play from over 40 acclaimed authors, including Nobel Laureate Sheldon Glashow, Michio Kaku, Peter Woit, Adam Roberts, Colette Inez, Brenda Hillman, Joseph Radke, Bruce Holland Rogers, and Carole Buggé.

"Sean Miller and Shveta Verma have put together an exhilaratingly eclectic anthology of creative and expository writing about one of the most exciting (even if controversial) intellectual fields of our time: string theory. Just Miller's erudite introduction by itself is worth the price of this sparkling collection."
– S. Abbas Raza, Managing Editor of *3 Quarks Daily* <http://3quarksdaily.com>

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– Sean Carroll, Theoretical Physicist, California Institute of Technology & Creator of *Cosmic Variance* <http://cosmicvariance.com>

"It is very surprising to me that string theory has entered the public consciousness to such a large degree, as documented by this book. This is probably due to the effectiveness of a few popularizers and the seeming craziness of its concepts. This book demonstrates that, in addition to practical applications, scientific research can also have cultural impacts."
– John H. Schwarz, Harold Brown Professor of Theoretical Physics, California Institute of Technology

"The jury is still out on whether string theory serves to explain the nature of reality, but the writers who have contributed to *Riffing on Strings* convincingly demonstrate that it serves very well as a springboard for the imagination. From Sean Miller's cogent introduction on, this is an engaging—and much-needed—dialogue between art and science."
– Frank Wilson, Former Book Review Editor, *The Philadelphia Inquirer* & Creator of *Books, Inq.* <http://booksinq.blogspot.com>

In praise of Carole Buggé's play *Strings*:

"I was amazed to see how Carole Buggé found inspiration in new ideas about the origin and future of the universe and in a real historic scientific incident (in which I played a role) and transformed them into a backdrop for an amusing and penetrating exploration of the human condition."
– Paul J. Steinhardt, Professor of Physics, Princeton University & Co-Author of *Endless Universe: Beyond the Big Bang*

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Introduction

Sean Miller

Like many people, my first encounter with string theory was through Brian Greene's book *The Elegant Universe*, which came out in the U.S. in 1999. I had always been interested in physics. In particular, I was intrigued by the physics that treated the peripheries of our capacity to experience the world—the realm of the incredibly small, the microcosmos, and the realm of the mind-bogglingly large, the macrocosmos in all its awesome vastness. And here was string theory, a scientific theory that promised to knit these two seemingly disparate worlds into one integral whole. A theory of the tiny and the humongous rolled up into one neat, elegant formalism. It is for this reason that string theory has been called a theory of everything. Little did I know then, as I tussled enthusiastically with the ideas in *The Elegant Universe*, that it would set me on a trajectory that I still find myself on to this day.

Physicists mean something specific when they speak of a theory of everything. They certainly do not mean to suggest that string theory can explain why sunflowers lean to the light or why people fall in love. What they mean by a theory of everything is this: string theory holds the potential to reconcile the two great high energy physics theories of the past century into one consistent mathematical formalism. Those two theories are quantum theory, the reigning theory for explaining the workings of the realm of the very small, and Albert Einstein's theory of general relativity, which explains with great precision the realm of the vast. General relativity is a theory of gravity, of how massive objects attract each other—it pertains to things like cannon balls, rockets, planets, stars, galaxies, galaxy clusters, black holes, and the entire universe itself.

In the early part of the twentieth century, quantum theorists found that the atom is, in fact, divisible. It is made up of a nucleus and an electron "shell" or "cloud" that orbits the nucleus. As you may recall from high school physics, the atomic nucleus is made up of subatomic particles called protons and neutrons. In the seventies, quantum theorists discovered that these protons and neutrons aren't fundamental either—they too are made up of smaller parts, what Nobel Laureate Murray Gell-Mann whimsically called "quarks," from a line in James Joyce's *Finnegans Wake*. Quarks and electrons—the fundamental ingredients of all matter. Quantum theory has enjoyed unparalleled experimental success. And yet physicists find it unsatisfactorily incomplete. Most glaringly, it does not incorporate gravity.

Enter the string. String theory claims that all the subatomic particles described by quantum theory—the quarks and electrons that make up matter, as well as all the subatomic particles that express force—are actually different vibrations of a more fundamental object, the string. Strings can be either closed like a loop or open like a wiggly filament. A string only looks like a particle when you view it from a distance, much in the same way that a house, an extended object, looks like a dot when gazing down from the window of a jet at 30,000 feet. The most powerful instruments today—that are able to peer into the microcosmos—can only probe distances of a few orders of magnitude below the scale of the atomic nucleus. That is why, according to string theorists, quarks and electrons appear to us as points. Strings, on the other hand, are on the order of 10^{-34} meters, what string theorists call the Planck length, named after the famous German Nobel Laureate Max Planck. That's a hundred billion billion billion times smaller than a speck of dust! Brian Greene writes: "To get a sense of scale, if we were to magnify an atom to the size of the known universe, the Planck length would barely expand to the height of an average tree."

Physical theories such as string theory deal with the fundamental objects that constitute our world and how they interact with each other. Matter either attracts or repels other matter. This attraction or repulsion at different scales and under different conditions is what physicists call force. As you know, gravity is a force of attraction. But gravity is very weak at atomic scales. It is only on scales of cannon balls, jets, and stars—where much matter has accumulated—that the force of gravity plays a significant role. Physicists have also nailed down three other forces that come into play on atomic scales. They are electromagnetism, the strong nuclear force, and the weak nuclear force.

Quantum theory describes accurately these three other forces. Electromagnetism, of course, can either attract or repel matter, depending on the charge, negative or positive, of the matter involved. The strong nuclear force binds quarks together in the nuclei of atoms. It is an attractive force. The weak nuclear force repels subatomic particles under certain conditions—and is responsible for certain kinds of radioactive decay. Quantum theory is incredibly accurate at describing the interaction of matter on atomic scales in terms of these three fundamental forces.

General relativity is highly effective at describing gravity on large scales. It essentially says that matter is a form of energy and that that energy constitutes space and time itself. Furthermore, space and time warp around massive objects, such as stars, because of the energy manifest in those objects. In extreme cases, such as within a black hole, the force of gravity is so powerful—that is, the amount of matter present is so vast—that even light cannot escape its gravitational pull. Yet general relativity is inadequate when it comes to describing black holes because a black hole is not only very heavy, it is also very small. All that matter has been compacted down to atomic scales. This represents a situation where quantum theory should be applied.

But when theorists try to apply both quantum theory and general relativity to natural phenomena that are both incredibly dense and incredibly small—such as black holes and the very early universe before its explosive expansion—both theories give nonsensical answers. String theory, because it incorporates consistently the force of gravity, as well as the three fundamental forces of quantum theory, promises to overcome this conflict. It is a quantum theory of gravity. This is what gets string theorists so excited about its prospects.

A few years back, I did a Masters course in literature at Birkbeck College, University of London. In the spring, Steven Connor gave a lecture that served as the spark that ignited my growing interest in string theory as a cultural phenomenon. At the risk of oversimplifying, I want to share with you the observation that Connor made that, in many respects, set me on my current path of research on the "cultural currency of string theory." In the talk, Connor spoke of the so-called Two Cultures, an expression made famous by the physicist and novelist C.P. Snow in 1959 to describe the breakdown in communication between those who worked in the sciences and those in the humanities. One consequence of this chasm was a tendency for humanities types—artists, writers, scholars—to make use of analogies and metaphors that were based on anachronistic scientific notions. Our imaginations—the underlying images and ideas that inform the structure of our thinking—are, in certain respects, still stuck on nineteenth-century scientific conceptions of the world, a world largely understood from a Newtonian perspective as mechanistic and deterministic, and where time advances linearly from past to present to future.

With Greene's *The Elegant Universe* buzzing fuzzily in my memory, I asked Professor Connor whether a contemporary physical theory such as string theory might offer us humanities types a perspective from which to re-imagine the social world that concerned us. He replied, yes, absolutely. Not one needing an excess of encouragement to fly off on a speculative tangent, my imagination grew increasingly fixated in the months that followed on this idea of how string theory as a worldview might influence contemporary culture in novel and interesting ways.

Of course, such flights of fancy come with a risk. One of the consequences of the rift between the Two Cultures is that when we in the humanities do evoke ideas from the so-called hard sciences, like string theory, those in the hard sciences tend to look upon our efforts with a certain derision. Humanities types, in turn, tend to view scientists with suspicion as well—as reductionists oblivious to the subtleties of language and culture. The chasm between the Two Cultures, this lack of understanding, has led to a general mood of mutual animosity and distrust.

One poignant example of this animosity is the notorious "Sokal Affair" of the mid-nineties. In 1996, Alan Sokal, a physicist at New York University, submitted a paper entitled, "Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity," to what was then a prestigious sociology journal called *Social Text*. At the time, *Social Text* was at the forefront of what is called in The Strong Program, an effort by postmodern sociologists to discredit the "objectivity" of scientific discourse.

Sokal intentionally riddled the paper with pseudo-scientific gibberish in order to back the claim that, as he puts it, "In quantum gravity […] the space-time manifold ceases to exist as an objective physical reality; geometry becomes relational and contextual; and the foundational conceptual categories of prior science—among them, existence itself—become problematized and relativized. This conceptual revolution, I will argue, has profound implications for the content of a future postmodern and liberatory science." Much to Sokal's surprise and delight, the editors at *Social Text* failed to vet the paper for its scientific inaccuracy and went ahead and published it. When Sokal revealed the paper to be a hoax, chock as it was with outrageous abuses of theoretical physics jargon, a controversy was born.

In a follow up book co-authored with Jean Bricmont called *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science*, Sokal writes: "When concepts from mathematics or physics are invoked in another domain of study, some argument ought to be given to justify their relevance." Of course, physicists like Sokal and Greene wouldn't place the same restrictions on other forms of artistic expression, such as science fiction. Safely in the realm of play, poetry and fiction are free to make use of ideas from hard science in whatever whimsical way they see fit. This is because they make no claims on the objectivity of the "real world." They deal with feelings, the imagination, and other "subjective" human phenomena.

This tidy sorting of subjectivity from objectivity is typical of those in the hard sciences, schooled as they have been in the dual philosophies of positivism and reductionism. Positivism and reductionism have had a profound influence in shaping the perspectives of the hard sciences such as theoretical physics. Simply put, positivism argues that what you cannot directly confirm or deny through experiment is not worth bothering with. From this perspective, any investigation of such things can only be idle speculation concerned with abstractions largely irrelevant to the real world. It is not physics, but metaphysics. As a complement to positivism, reductionism argues that complex worldly phenomena can best be understood by reducing them to their smallest and simplest constituent parts and understanding the rules of their interaction.

My own research tries to show that, with respect to string theory, this supposedly neat distinction between the imagination and the objective world is not so neat after all. And it is something that I believe the pieces in this collection demonstrate as well. In that spirit, the question central to *Riffing on Strings* is: what can we say and feel about the cosmos we live in through the prism of string theory imaginaries?

A Brief Tour of String Theory

For those of you who are unfamiliar with string theory, I offer you a brief tour of its most salient features—within the context of its history. If you're up-to-date on the topic, you may want to skip ahead to the next section of this introduction. Keep in mind, though, that the account that follows may add a few new twists to the string theory story that are well worth considering.

In its essence, the history of string theory is the story of people with highly specialized training working together to solve difficult problems within a well-defined field of activity. String theory began in the late nineteen-sixties, when theoretical physicists were trying to come to terms with the mysteries of the atomic nucleus. At the time, results from experiments conducted at the particle colliders physicists use to probe the structure of the subatomic world suggested that protons and neutrons were not, in fact, fundamental. In quantum theory, protons and neutrons belong to a class of subatomic particles called *hadrons*, a word which comes from the Greek *hadr-*, meaning heavy. They are the massive particles that, among other things, make up the nuclei of atoms. When experimentalists in the sixties smashed atoms together, they found that hadrons behaved in perplexing ways—as they flew further apart, the force between them seemed to get stronger.

At the time, there were several hypotheses proposed to explain this odd behavior. One was Richard Feynman's theory of *partons*. Another was Murray Gell-Mann's theory of *quarks*. Both of these theories, while significantly different in detail, took a reductionist approach. They argued that protons and neutrons could be explained in terms of smaller, constituent parts. Yet another was Geoffrey Chew's theory of the S-matrix. Unlike the parton and quark theories, Chew claimed that his approach was holistic. Simply put, it was the whole system, the S-matrix, out of which the parts, hadrons, emerged. Chew's theory was very fashionable among physicists at the time.

Then, in string theory lore, in 1968 along came an Italian postdoctoral fellow at CERN in Geneva, Switzerland named Gabrielle Veneziano. Veneziano was a disciple of Chew's S-matrix theory and was eager to make his reputation in the field. While scouring through an antique mathematical text authored by the eighteenth-century mathematician Leonhard Euler, he came across a formula, called a Beta function, which seemed like it could be used to model the strange behavior of hadrons. No one had a convincing explanation as to why the force that held hadrons together grew stronger the further the hadrons moved apart, much like a rubber band. The Beta function mathematically described elastic behavior like this. Veneziano published his idea in a professional journal and it caused a stir. Other theorists began to work on the problem using Veneziano's approach.

A couple of years later, Yoichiro Nambu, Leonard Susskind, and Holger Nielsen, all working independently, came out with papers that argued that the force that held hadrons together in the nuclei of atoms could best be described not as point-particles, as quantum theory stated, but as objects extending along an extra dimension. While all three used the expression "harmonic oscillator" to describe this strange new theoretical object, each one imagined it a bit differently. Nambu called it a "cavity resonator." A cavity resonator is an enclosed space where energetic excitations produce harmonic oscillations. Flutes and organ pipes are examples of cavity resonators—as is the body of a violin. Nielsen called his model a "fishnet diagram," where each strand of the fishnet represents one particular pattern of oscillation. Susskind likened his model to a "chain or springs" or "an ideal rubber band." But ultimately, it was Susskind, in another paper a year later, who named this new one-dimensional extended object a string. Like a rubber band, a string has tension. When plucked, that is, when it interacts energetically with other strings, it vibrates. The various modes of vibration—or to use a musical analogy, the notes—of a string precisely describe the scattering patterns of hadrons as they ricochet off each other.

Susskind tells the story of how the name stuck. Shortly after the publication of this second paper, he went to a big conference in Coral

Gables, Florida. Susskind suddenly found himself in an elevator with the great Murray Gell-Mann, who asked him what he did. Susskind replied, "I'm working on this theory that hadrons are like rubber bands, these one-dimensional stringy things." Gell-Mann began to laugh and laugh. Susskind writes:

> I didn't see Murray again for two years. Then, there was a very big conference at FermiLab, and a thousand people were there. And me, I'm still a relative nobody. And Murray is in constant competition with his colleague Richard Feynman over who is the world's greatest physicist.
>
> As I'm standing there talking to a group of friends, Murray walks by and in an instant turns my career and my life around. He interrupts the conversation, and in front of all my friends and closest colleagues, says […] "The stuff you're doing is the greatest stuff in the world. It's absolutely fantastic, and in my concluding talk at the conference I'm going to talk about nothing but your stuff."
>
> On the last day of the conference, off in the corner somewhere […] the next thing I heard was Murray holding forth. He was telling a group of his cronies everything I had told him. "Susskind says this, and Susskind says that. We have to learn Susskind's String Theory."

Still more theoretical physicists became interested in the topic, which led to a flurry of advances in this new "string theory" throughout the early seventies. However, in the meantime, Gell-Mann's theory of quarks was also making great strides. Improvements in collider technologies allowed experimentalists to probe the nucleus at smaller and smaller scales. Results from these experiments strongly corroborated Gell-Mann's quark theory over Susskind's string theory. Gell-Mann's theory of quarks has since become known as *quantum chromodynamics*, the theory of the strong nuclear force, which binds together atomic nuclei (it is a "chromodynamics" because different kinds of quarks have different "colors"—not actual colors but whimsically so). Quantum chromodynamics is a point-particle theory that describes the binding of the strong nuclear force in terms of the exchange of special particles called gluons (as in "glue") between sets of quarks. Joined with the theories of electromagnetism (*quantum electrodynamics* or *QED*) and the weak nuclear force (*electroweak theory*), the three fundamental forces have since come to be known as the Standard Model.

With the success of quantum chromodynamics in the mid-seventies, most physicists abandoned string theory. A small group of mavericks continued to tinker with it, though, hoping to modify string theory in order to make it more realistic. Instead of modeling hadrons, their strategy was to use string theory to describe not just the strong nuclear force, but the other two subatomic forces as well. This was known as *bosonic string theory*.

In the Standard Model, there are two main classes of subatomic particles, *bosons*, named after the Indian physicist Satyendra Nath Bose, and *fermions*, named after the Italian Nobel Laureate Enrico Fermi. All particles have what is called spin—a mathematical attribute like the spinning of a top. (A point particle, since it has no extent, cannot actually spin.) Bosons, most of which are considered force particles, have a spin of one. They return to their original state after one rotation. Fermions, most of which are considered matter, have a spin of one-half. They return to their original state after two rotations. In the early seventies, theorists succeeded in finding a way to use string theory to describe all the bosons in the Standard Model. They also made the theory consistent with Einstein's theory of special relativity, an important part of general relativity which demands that no particles may travel faster than the speed of light.

There was one striking consequence in reformulating string theory to model bosons. In order to be mathematically consistent, the tiny vibrating strings of energy had to exist in 26 dimensions of spacetime—that is, in one dimension of time and twenty-five of space! Our bodies move in three dimensions of space—back and forth, up and down, and left and right. We understand the universe in its entirety as having four spacetime dimensions, three of space and one of time. Needless to say, it is difficult to comprehend the meaning of 25 dimensions of space. This need for 26 spacetime dimensions in bosonic string theory was met with a great deal of skepticism from the physics community.

In 1975, theorists Joel Scherk and John Schwarz published a paper that extended string theory to incorporate not only bosons, but fermions as well. This new version of string theory could now generate a close approximation of the entire spectrum of particles in the Standard Model. But by including fermions with bosons, Scherk and Shwarz found that, in order to be mathematically consistent, the strings had to reside not in 26, but 10 spacetime dimensions. One surprising result of this synthesis was that a set of string vibrations for gravity naturally emerged from their model. Because string theory naturally included gravity, they reasoned that it may very well be a legitimate quantum theory of gravity. This was the move that inspired some physicists to believe that perhaps string theory could indeed be a theory of everything. Another result of Scherk and Schwarz's new version of string theory was that the scale of the string shrank from the scale of hadrons, about 10^{-16} centimeters, to the Planck scale, or 10^{-33} centimeters. Yet there were still several nagging inconsistencies in Scherk and Schwarz's theory of strings for bosons, fermions, and gravity.

These inconsistencies were ultimately resolved with the incorporation of yet another theory—*supersymmetry theory*. In a nutshell, supersymmetry provides a way for bosons and fermions to transform into one another. In quantum theory, the various classes of particles are organized into three groups of what are called gauge transformations—ways that these particles may change when they interact with other particles. The expression "gauge" comes from nineteenth-century railroad terminology, where different track widths were classified as gauges. There is a gauge group in quantum theory for each of the three fundamental forces: the electromagnetic gauge, the strong gauge, and the weak gauge.

In quantum theory, there is no obvious connection between these three forces and their corresponding gauge groups. They are simply cobbled together as a kind of hodgepodge, each pertaining to its own relevant situation. Supersymmetry promises to unite these three disparate gauge groups into one supergroup. This supergroup allows for certain rigidly defined transformations amongst all its members. In a supersymmetric world, a boson may transform into a fermion and a fermion may change into a boson. What this means is that each boson in the Standard Model has a superpartner fermion. Accordingly, each fermion has a superpartner boson. No one has ever observed these superpartners in nature, but one of the goals of the new collider going online in 2008 at CERN, the Large Hadron Collider, is to search for these superpartners.

While supersymmetry theory is independent of string theory—it has also been incorporated into current versions of point-particle quantum theories—the discovery of such superpartners in nature would help string theory's case considerably. This is because supersymmetry complements string theory in elegant and precise ways. The first to successfully incorporate supersymmetry into string theory were the theorists F. Gliozzi, J. Scherk, and D. Olive in 1976. But shortly afterwards, theorists faced a number of intractable problems within this exciting new *superstring theory* that prompted other physicists to disregard it, especially in light of the continued success of the Standard Model. Two physicists who persisted, against the odds, in their work on superstring theory were John Schwarz and Michael Green. In 1981, Green and Schwarz were able to make superstring theory consistent with special relativity. In 1984, they were able to resolve a nagging issue with what are called "anomalies," mathematical inconsistencies that previously rendered their theory hopelessly unrealistic. Most string theorists consider 1984 a watershed moment in the ascendancy and subsequent institutionalization of superstring theory. Their solution to these substantial problems in superstring theory made Green and Schwarz instant celebrities within the physics community.

In the wake of their success, many more talented physicists joined the growing flotilla of those working on superstring theory. There was a widespread sense that a breakthrough of historical proportions was teasingly just over the horizon. Out of this flurry of intensive research came four alternative versions of superstring theory. In 1985, David Gross, Jeffrey Harvey, Emil Martinec, and Ryan Rohm, all working at Princeton University, proposed what has come to be recognized as the most successful of these anomaly-free superstring theories in reproducing a "semi-realistic" quantum particle spectrum: Heterotic $E_8 \times E_8$ Superstring Theory. The odd thing about heterotic superstring theory, though, is that unlike the others, which include 10 spacetime dimensions, it couples a gauge group that requires 10 spacetime dimensions to one of 26 spacetime dimensions. This is what makes it "heterotic," from the Greek meaning "different." It strikes me as ironic that the most "realistic" superstring theory, the one that supposedly most resembles our universe, is also the weirdest in terms of its mathematical structure.

The five versions of superstring theory differed enough to pose a serious problem: which one was the correct one? It was an embarrassment of riches. Most physicists feel that a theory should carry with it a sense of inevitability. Inevitability requires that only one unique theory ought to be the correct one and that its correctness can be borne out by its making specific, testable predictions that other theories do not. None of the five competing superstring theories proposed in the mid-eighties suggested such an inevitability.

The confusion that ensued over this embarrassment of versions was further exacerbated by the problem of what to do with the six extra spatial dimensions. At best, superstring theories can only produce what theorists call "semi-realistic" physics. By "semi-realistic" they mean a given theory can produce a particle spectrum that closely resembles the particle spectrum of the Standard Model but not exactly. There are loose ends, gaps, extra elements, niggling inconsistencies. One strategy for making these superstring theories realistic is to tinker with the geometry of the extra spatial dimensions. It is assumed that since experimental equipment cannot detect these extra dimensions, they must be small, on the order of the Planck scale.

As a consequence, in the late eighties, theorists concerned themselves with formulating the various superstring theories where these extra dimensions were compactified—made tiny and bundled together. At the time, the issue was how to describe these ultramicroscopic bundles of extra dimensions. String theorists found some success using a funky geometrical object that had been explored by an Italian-American mathematician, Eugenio Calabi, back in the late 1950s. Calabi's conjecture was subsequently proved in 1977 by the Chinese mathematician, Shing-Tung Yau. In honor of their discoverers, these balled-up, contorted, knot-like multidimensional objects are called *Calabi-Yau manifolds* (also sometimes referred to as Calabi-Yau "shapes" or "spaces").

While Calabi-Yau manifolds tantalized string theorists with the prospect of the perfect shape to generate a realistic particle spectrum, finding the correct one proved to be elusive. There are millions upon millions of potential candidates—many of them produce semi-realistic physics—but none has been shown to produce the exact solution. To compound the problem, it is a painstaking process to sift through all the promising candidates. Theorists have also fiddled with comparable multidimensional geometric objects called *orbifolds* and *orientifolds*, but, as of this writing, the verdict is still out.

So not only are there five competing versions of superstring theory to contend with, there are millions of potential ways to configure the extra-dimensional spaces within these theories. In effect, there are millions of superstring theories to choose from, none of which is more than, at best, semi-realistic.

Then in 1995, at the annual Strings conference, Edward Witten proposed a striking new passage through this theoretical impasse. In a lecture that shocked and enthralled his audience, Witten argued that the five superstring theories may, in fact, be different formulations of a more fundamental theory, which he later dubbed *M-theory*. Witten has said that the "M stands for magic, mystery or membrane, according to taste." Others have suggested that the M stands for "matrix," since the theory makes use of infinite-dimensional matrices. Still others suggest that the M stands for "mother" as in "the mother of all theories." The more skeptical have offered yet more decipherings of the M in M-theory. It might be an upside-down W, and thus a small gesture of self-aggrandizement on Witten's part. Or it might as well stand for "murky" or "monstrous," since M-theory promises much but actually resolves little. Theorist Michael Duff has facetiously called M-theory "the theory formerly known as strings."

One notable feature of Witten's M-theory is that by teasing out the equivalences among the various superstring theories, spacetime winds up having not 10 spacetime dimensions, but 11. Another feature of M-theory is that strings, the supposed fundamental objects of the universe, take a back seat to the brane, short for membrane. While strings are extended one-dimensional vibrating objects, branes are two or more dimensional extended objects. A useful analogy is to imagine a violin string. When a violin string is plucked, it vibrates at a certain frequency, depending on the length of the string. We hear this as a particular note. Now imagine a brane as a drumskin. When a drumskin is hit, it also vibrates at a certain frequency, a particular "note." We can now extrapolate this analogy by adding additional dimensions to the brane.

In M-theory, the universe is composed of a variety of different branes, categorized by the number of dimensions they possess. A 0-brane is a point-particle-like object. A 1-brane is a particular kind of string. A 2-brane is a two dimensional membrane, like a drumskin. A 3-brane has three spatial dimensions, and so on, up to a 10-brane. (Remember that one dimension corresponds to what we experience as time.) Michio Kaku's essay in this collection, "M-Theory: The Mother of all Superstrings," goes into more detail about the importance of branes in M-theory.

Most recently, theorists have been calling into question the assumption that these extra spatial dimensions in M-theory must be compactified. There have been some suggestions that the extra dimensions, while still beyond the reach of our instruments, are larger than the Planck scale, and therefore may be just tantalizingly out of reach. Another line of inquiry in current research explores the possibility that the extra dimensions may be extremely large, on cosmic scales. These models are often called "braneworld scenarios." In some of them, our four-dimensional universe is situated on a 3-brane that, in turn, resides within an eleven-dimensional meta-verse, often called "the bulk."

One peculiar version of the braneworld scenario argues that there is a nearly infinite number (10^{500} or thereabouts) of such braneworlds in the bulk. Each of these braneworlds has laws of physics that vary from its neighbors. That variation, however minute, alters the basic composition of matter and force within the braneworlds. To explain why we in our universe find the particular balance of matter and force that would allow for our very existence as human beings, such models evoke what is called the Anthropic Principle. Physicist P.C.W. Davies defines the Anthropic Principle thus: "we should observe a universe of minimal order consistent with the existence of observers." The Anthropic Principle suggests that the very fact that we humans are here demonstrates that the universe we live in must be finely tuned. That is, the laws of physics must be such that they generate the particular balance of matter and force that results in the stars, planets, chemistry, and ultimately the complex biology which we as human beings represent. For if our universe were not so finely tuned, we could not have come about.

The question then becomes: how is it that our universe is so finely tuned? Landscape Theory, as it is called, answers this question by suggesting that it is highly plausible that just such a universe as ours is bound to come about in a bulk that contains 10^{500} braneworld universes. With that kind of variety, our particular universe—finely-tuned as it is—is only special in that it is the one that happens to have produced us.

As a matter of convenience, I will refer to this panoply of theories under the umbrella term “string theory,” even though, strictly speaking, there is no one correct and inevitable string theory *per se*. Shuffling all these string-related theories into the bucket category of string theory is simply a matter of rhetorical convenience.

To briefly review: according to string theory, the universe is composed of certain basic ingredients. They are the string, the brane, and extra dimensions. The string is a one-dimensional extended object that vibrates. It can be open, like a filament, or closed, like a loop. A string has tension. The amount of tension in the string determines at what frequency the string resonates, and as a consequence, what quantum particle the string becomes. The various resonance modes of the string generate the entire particle spectrum—all quantum particles of matter and force, including gravity.

String theory also contains another fundamental object called the brane. A brane is a two or more dimensional extended object. Like strings, a brane has tension and vibrates in a certain range of frequencies. This set of resonances determines the behavior of the brane in relation to other branes (and strings).

We traditionally understand our universe to have three dimensions of space and one of time. But in order for string theory to be mathematically consistent, the universe must have either 26, 10, or 11 spacetime dimensions, depending on which version of string theory we consider. Bosonic string theory needs 26 spacetime dimensions in order to be mathematically consistent. Superstring theory needs 10, and M-theory needs 11. Some string theory-based models compactify the extra dimensions into various knot-like geometric structures, such as Calabi-Yau manifolds. Other models extend the extra dimensions out to cosmic scales.

There is a great deal of controversy in the physics community over whether these extra dimensions are real or are actually just mathematical artifacts. And since strings, branes, and extra dimensions reside on scales impossibly remote from the reach of our scientific instruments, we may never hope to verify their existence through experiment. Peter Woit, whose piece in this collection pokes subtle fun at these and other "metaphysical" aspects of string theory, echoes the famous quantum theorist Wolfgang Pauli when he suggests that string theory is "not even wrong." The essay "Desperately Seeking Superstrings?" by Nobel Laureate Sheldon Glashow and ArXiv.org creator Paul Ginsparg also bitingly critiques string theory as physics gone astray.

String Theory as Scientific Imaginary

What I have given here is a whirlwind tour of string theory that does not do justice to its subtleties. If you are hungry for a more thorough explanation of string theory, I've provided a list of suggested readings at the back of the book. As an object of study, string theory is deep and multi-faceted. You can approach it from a host of perspectives.

A full appreciation of string theory must contend with the controversy surrounding its legitimacy as science. Does string theory simply reduce to frivolous conjecture and mathematical pyrotechnics? Is it satisfying to accept that extra dimensions are hidden because of our current technological limitations, or are they merely misleading figments of the imagination? Will string theory ultimately provide humanity with a theory of everything, one "master equation," as Brian Greene puts it, out of which all the mysterious workings of the universe are laid bare?

Adding flavor to these still as yet unresolved questions are the curious details of string theory's history. Ed Witten has said that "superstring theory is a piece of twenty-first-century physics that fell by chance in the twentieth century." In many respects, the problems of string theory are so obdurate that not only can no one solve them, but theorists simply lack the mathematical tools to do so. These tools have yet to be invented. As such, if Gabrielle Veneziano hadn't stumbled upon that antique formula of Leonhard Euler's back in 1968, would there even be a string theory as we know it today? And now that we find ourselves firmly planted in the twenty-first century, will our mathematics catch up with string theory's various mysteries?

These questions are further complicated by how theoretical physics itself gets produced. There are currently about a thousand string theorists engaged in active research in the world. It takes many years of training to gain the skills necessary to participate in the string theory technical conversation. String theory as a professional practice is an exclusive coterie. Even those who work in related disciplines, such as quantum field theory or general relativity, have a hard time understanding its argot. Lee

Smolin of the Perimeter Institute, who specializes in an alternative to string theory called "loop quantum gravity," writes: "Even now, one can go to a conference and find that string theory and loop quantum gravity are the subjects of separate parallel sessions. The fact that the same problems are being addressed in the two sessions is noticed only by the small handful of us who do our best to be in both rooms." In some respects, an inevitable consequence of the advancement of scientific knowledge is its ever-increasing fracturing through specialization.

Since the mid-1990s, string theorists have been making a concerted effort to share their work with a wider, non-specialist audience, perhaps out of concern for their relative professional (and theoretical) isolation. The first attempts to popularize string theory to a lay audience occurred in 1987 with Michio Kaku and Jennifer Trainer's *Beyond Einstein* and P.C.W. Davies and Julian R. Brown's *Superstrings: A Theory of Everything?*. Since then, popular accounts of string theory have been coming out with increasing regularity. With the success of such works as Kaku's *Hyperspace* in 1994 and Greene's *The Elegant Universe* in 1999, string theory has thoroughly infiltrated public awareness.

References to string theory pop up in the oddest of places. For instance, in the debut season (2007) of the CBS sitcom *The Big Bang*, its two main characters, both young male physicist nerds, debate, in a glib fashion typical of primetime TV, the merits of "bosonic string theory." They do this to impress a female colleague whom one of them hopes to seduce, however clumsily. There is a trilogy of *Star Trek Voyager* novels subtitled *String Theory*. In the Wikipedia entry for string theory, a section towards the bottom of the page lists pop culture references. Needless to say, these references and more extended treatments of string theory continue to multiply.

These are, of course, isolated examples, but they serve to highlight what you might call the second phase in the dissemination of scientific ideas. The first phase is didactic. This is where scientists themselves—sometimes with the help of journalists—introduce their disciplines and discoveries to a non-professional audience. Through such efforts, scientists hope to educate non-specialists for more or less three reasons: one, from a genuine desire to share their enthusiasm for their subject; two, in order to recruit young people to the profession; and three, to gain enough popular support for their research such that it will eventually contribute to continued public funding, since most scientists work for universities that depend on both government grants and alumni support.

In the second phase, the key ideas of a scientific discipline enter the wider popular dialogue as buzz words. These ideas are dropped in passing—around office coolers or at cocktail parties—as a kind of status symbol that shows those who evoke them to be savvy consumers of the cutting-edge. Lisa Randall writes:

> I realized how much attention [M-theory] was receiving when I was on a plane returning from London. A fellow passenger, who turned out to be a rock musician, saw that I was reading some physics papers. He came over and asked me whether the universe had ten or eleven dimensions. I was a little surprised. But I did answer and explained that in some sense, it is both. Since the ten- and eleven-dimensional theories are equivalent, either one can be considered correct.

But with respect to this collection, it is the third phase in the dissemination of string theory as a "scientific" idea that most interests us. This is where the images associated with a scientific theory become detached from that theory's formal expression and take on a life of their own. In the case of string theory, its formal expression is couched entirely in the language of mathematics. To understand the mathematics of string theory, you need to be a professional. There are precious few non-professionals in the world who can say with confidence that they can read and understand the mathematical arguments made in string theory technical discourse. Those arguments must both be understood in their own terms—the consistency of the mathematics itself—and in terms of the broader context of accepted physical theory and potential experimental evidence to support the claims of those arguments. A science such as string theory must, in this sense, corroborate the successes of its predecessors—quantum theory and general relativity—while also shedding new light on heretofore unresolved mathematical and evidential inconsistencies in those predecessors.

But culture at large—a lay audience that includes other scientists who do not specialize in string theory—has no access to the formal conversation of string theory. We only have access to its exposition. Playing off the etymological root of the word "exposition," as a lay audience, what we get with string theory is that which has been "put out" or exposed to us. It is a string theory mediated through expository prose and, most significantly, the imagery that constitutes that prose.

We are accustomed to thinking of concepts as something categorically distinct from imagery. Mathematical arguments are surely an extremely sophisticated form of conceptualization. But what we often don't appreciate is that the concepts we make use of in ordinary expression—in the prose of popular accounts of science, for example—come riddled with images. These images do not merely adorn concepts. They are not tossed into the mix merely to make those concepts more "clear" and accessible. Images are, in fact, fundamental to exposition—and to the conceptualization that exposition represents. I challenge you to think of a concept that, at its root, does not arrive as a shell with some image tucked within it. Reason depends integrally on the imagination. The two cannot be purified of each other.

An impassioned defense of this position, which might strike some of you as far-fetched, is beyond the scope of this introduction. As a proxy, I offer you this passage from linguists George Lakoff and Mark Turner's book, *More Than Cool Reason*. It addresses this classic debate between old school literalists and second-generation cognitive scientists (in reading this excerpt, remember that metaphors are made of images):

> The Literal Meaning Theory entails [...] the assumption that reason and imagination are mutually exclusive. Reason is taken to be the rational linking up of concepts, which are nonmetaphoric, so as to lead from true premises to true conclusions. Thus, there is nothing metaphoric about reason, neither its operations nor the concepts it operates on. Metaphoric reasoning, on this view, cannot exist. Since metaphor is excluded from the domain of reason, it is left for the domain of imagination, which is assumed to be fanciful and irrational. This view is, as we have seen repeatedly, erroneous. Many of our inferences are metaphoric: we often reason *metaphorically*, as when we conclude that if John has lost direction, then he has not yet reached his goal. Our reasoning that time changes things is metaphoric and deeply indispensable to how we think about events in the physical, social, and biological worlds. Indeed, so much of our reason is metaphoric that if we view metaphor as part of the faculty of the imagination, then reason is mostly if not entirely imaginative in character.

In keeping with this perspective, let's examine the image of the string in string theory. Here is a formula from bosonic string theory called the Nambu-Goto Action:

$$S = -\frac{T_0}{c}\int_{\tau_i}^{\tau_f} d\tau \int_0^{\sigma_1} d\sigma \sqrt{(\dot{X}\cdot X')^2 - (\dot{X})^2 (X')^2}\,.$$

The Nambu-Goto Action, named in honor of its inventors, the Japanese theorists Yoichiro Nambu and T. Goto, describes the "string action" of a one-dimensional string as it sweeps through a quantum-theoretical version of time. The variable "*S*" in the formula represents the total surface area of a string's worldsheet, that is, the area covered as it sweeps through spacetime. I share this bit of string theory esoterica not to intimidate you with highfalutin math, but to demonstrate that to decide to call the "object" within this formula a string is, in many respects, arbitrary. It is a matter of convenience that helps theorists to imagine more effectively the mathematics with which they work.

Sure, the image of the string may be more or less apt. Strings that we are familiar with in everyday experience behave in ways that are more or less appropriate for describing a theoretical object that might exist on the incredibly remote and alien Planck scale. But there is no abiding reason to assume that what we understand as objects on human scales—things we can see and grasp—have any meaning on scales where what we "see" and "grasp" are mediated by mathematical arguments and data collected from instruments.

In effect, when theorists "expose" string theory to themselves and to us, a lay audience, what we are getting is not the science *per se*, but a *scientific imaginary*. A scientific imaginary is a complex of images that gestures towards a coherent worldview. A worldview is a way of looking (a view) coupled to a world that is readily viewable. We imagine a new worldview by recombining in novel ways human-scale images from existing worldviews. These images are based on objects and events drawn from everyday experience—with which we are relatively familiar and thus, are relatively easy to comprehend. I stress the qualification "relatively," because it is the novelty in the recombinations of these images that makes a scientific imaginary feel weird and incredible. A scientific imaginary is most appealing when it manages to find that ideal mixture of strangeness and familiarity. It is just the right amount of weird.

A scientific imaginary offers us a whole world, even though it may not succeed in fulfilling its intention to be coherent. As a whole, a scientific imaginary engenders a worldview. The worldview is the whole—that amalgam of images and their rules of interaction that attempts to extrapolate the whole from its parts. As a reductionist strategy, string theory declares, in its crudest articulation, that the world is made of strings. In this sense, string theory is atomistic. Atomism here is synonymous with reductionism—a strategy whereby the whole is understood in terms of its smallest constituent parts. Reductionism is a kind of worldview where *the parts are more than the whole*, the reverse of holism.

But a worldview also, importantly, contains a view: not only is it a world, but also the human agency that engages with it. A worldview, in this sense, is synoptic. One view, formed through consensus, gathers together a whole. The two elements are stitched together—a world and those who would recognize it as such.

We can think of a string theory imaginary as a particular kind of worldview: as a cosmology. It is important here, though, to distinguish cosmology as an imaginary and cosmology as scientific practice. Within physics, cosmology is a distinct discipline. Cosmologists try to understand the universe on the largest of scales by means of theoretical models extrapolated from telescopic observation: the dynamics of solar systems, black holes, galaxies, and galaxy clusters. They work from the assumption that the universe on the vastest of scales can be understood as an ordered whole.

To speak of a string theory imaginary as a cosmology is to recognize that the word *cosmos* has a more expansive connotation than *world*. Where world often implies solely planet earth apprehended on human scales or global scales (for example, to speak of world peace), cosmos clearly designates the universe in all its vastness and totality. Yet the word cosmology also conjoins the outside with the inside, a *cosmos* with a *logos*, its apprehension and comprehension. For our purposes, then, a cosmology mediates the interaction between nature, the objective world out there in its fullest range from microscopic to macroscopic, and culture, the social agencies and practices of a human community. A cosmology, then, is an imaginary situated between culture and nature. It implies: a signifier, the cosmos; a signified, its cultural meaning; and those who are doing the signifying.

Contemplation of the cosmos has always held a great deal of emotional power. The word *cosmos* also comes from the ancient Greek. Originally, *cosmos* meant order or that which is well arranged. *The Oxford English Dictionary* defines *cosmos* as "the world or universe as an ordered and harmonious system." It was Pythagoras and his followers that extended the meaning of *cosmos* from "order" to the world because they saw in the world an "order and arrangement." For Pythagoras it was number that perfectly expressed the order in the world.

The word *universe* is the Roman counterpart to *cosmos*, and in Latin it literally means "one turn." The *OED* defines *universe* as "the whole of created or existing things regarded collectively; all things (including the earth, the heavens, and all the phenomena of space) considered as constituting a systematic whole." Perhaps one reason why we, more often than not, face the vastness of the cosmos with a sense of reverence and awe is that it defies direct apprehension. Even for the ancient Greeks, the world was a vast place with literal and figurative frontiers, past which there was only the unknown. In the face of this utter vastness, there's something incredibly bold about the act of defining the universe as one turn, one grand, sweeping act of imagination. How hubristic to conceive of the vast multitude of all things, ideas, and places—of which we are and will ever be only dimly aware—as one ordered and harmonic whole! There is also something incredibly wishful and innocent about it. Today, our image of the cosmos has changed significantly from that of the ancients. Those far-off frontiers that seemed so unassailable to them, we have painstakingly, over the course of centuries, pushed further and further back.

In her groundbreaking study of the particle physics community, *Beamtimes and Lifetimes*, anthropologist Sharon Traweek defines culture as "a group's shared set of meanings, its implicit and explicit messages, encoded in social action, about how to interpret experience." The converse of this definition also proves true: a culture is a shared set of social practices encoded in a symbolic structure. Action in the world determines what the world means, just as what that world means informs action.

Traweek's emphasis is sociological. She is referring to social action within the physics community: theorists doing calculations on scratch-pads, whiteboards, or computers; theorists attending conferences, conversing with other theorists, publishing papers, exchanging emails, etc. Unlike Traweek's work, the pieces in this collection are not concerned so much with showing the specific social practices of string theorists in the doing of physics and how those practices shape their understanding of the world.

Rather, in reading these pieces, notice how the writers portray, through their own particular version of a string theory imaginary, people interacting with each other *and* with things in the world. Within each string theory imaginary, then, we can examine the extent to which social action generates interpretation just as interpretation, that "shared set of meanings," generates social action. We can ask, to what extent are these two flows of meaning and interaction, in seemingly opposite directions, mutually constituting?

From this perspective, then, the contrast between nature and culture becomes more a matter of emphasis. Within an imaginary, the objective world becomes a projection of a community's self-regulating structure of social actions—and vice versa. This coupling of cosmos with culture, this cosmology, is an idea given currency by the early twentieth-century sociologist Émile Durkheim. Traweek paraphrases what she calls the "Durkheim supposition" thus:

> [A] culture's cosmology—its ideas about space and time and its explanation for the world—is reflected in the domain of social actions. In other words, ideas about time and space structure social relations, and the spatial and temporal patterns of human activity correspond to people's concepts of time and space.

A culture's notions of the world it inhabits (space and time) inform its social practices (patterns of activity) while its social practices shape its notions of the world.

In the context of a scientific imaginary such as string theory, then, to speak of culture is to focus on what the French philosopher Michel Serres calls "our relations among ourselves," while to evoke nature is to emphasize "our rapport with things." Serres uses the example of the post-war space program to highlight this interlacing of culture and nature: "Every technology transforms our rapport with things (the rocket takes off for the stratosphere) and, at the same time, our relations among ourselves (the rocket ensures publicity for the nations that launch it)." He continues: "This object, which we thought simply brought us into relationship with the stars, also brings us into relationship among ourselves." In this sense, scientific imaginaries cross-fertilize with "cultural" imaginaries, where an emphasis of orientation "out there" or "among us" determines an imaginary's status and function. Playing on the etymology of the words "rapport" and "relate," we "carry" how we imagine the cosmos back into the community and, in turn, we "carry" how we imagine the community back into the cosmos.

With string theory, the objects that concern us are not technological *per se*, like Sputnik or the Apollo Saturn V rocket, but theoretical. A string theory imaginary—and the things that populate it—finds its greatest currency in a consumer culture that puts a premium on the trafficking of scientific ideas, where the bandying about of scientific ideas becomes yet another means for displays of status. Scientific ideas become an intellectual surplus in an economy of exchange where the cachet of a given scientific idea stems from its novelty, its sexiness, its obscurity. A string theory imaginary finds its place in a culture of informationalism, a culture that marks scientific knowledge as the last frontier, where the unveiling of the hidden essence of nature becomes a peripatetic lurch at the virtual quasi-domestication of the alien on incredibly remote scales. It is an arguably myopic, if not solipsistic culture, where, as the sociologist Manuel Castells suggests, "[w]e are just entering a new stage in which

Culture refers to Culture, having superseded Nature to the point that Nature is artificially revived ('preserved') as a cultural form."

Keeping the "Durkheim supposition" in mind, let's explore four examples of scientific imaginaries. The first comes from Bertrand Russell's famous *The ABC of Relativity*, first published in 1925. In this passage, Russell draws a link between the physics concept of force and politics:

> If people were to learn to conceive the world in the new way, without the old notion of "force," it would alter not only their physical imagination, but probably also their morals and politics. [...] In the Newtonian theory of the solar system, the sun seems like a monarch whose behests the planets have to obey. In the Einsteinian world there is more individualism and less government than in the Newtonian.

This quote illustrates how a scientific imaginary works. Both the "Newtonian theory" and Einstein's special relativity are theories expressed in the language of mathematics. Russell conflates an expository explanation of these theories, what he calls "their physical imagination," with the theories themselves. This, in turn, allows for an easy imaginative leap to the discursive domains of "morals and politics." Sokal and Bricmont would certainly argue that such an imaginative leap betrays an inappropriate adaptation—a distortion. Russell hijacks the authority of Einstein's theory to champion a liberal (if not libertarian) political allegiance, one that valorizes individualism and decentralized government.

The second example comes from Mary Midgley in her book *Science and Poetry*: "[T]he social development of individualism increased the symbolic appeal of physical atomism, while the practical successes of physical atomism made social individualism look scientific." Like Russell, she writes of the relationship between Newtonian cosmology and "social individualism." In this cultural configuration, the image of the atom and the image of the human individual become mutually reinforcing. But rather than co-opting a scientific imaginary to promote a political view, Midgley calls attention to the coupling of that imaginary to the culture in which it flourishes. We get a sense that Midgley is aware of the fissure between actual Newtonian theory and a scientific imaginary based on it. Unlike a positivist perspective—that envisions a chasm between the conceptual content of scientific practice and the imaginative content of non-scientific discourse—Midgley here recognizes the amplifying feedback that a scientific imaginary can supply to an ideological agenda.

Scientific imaginaries fill the gaps between context-specific theoretical arguments so thoroughly that to conceive of the dichotomy between science and its ostensibly lesser sister, the imagination, as an unbridgeable rift is to deny the extent to which imaginaries support and sustain scientific arguments. To recognize this is to better understand the extent to which, in the case of a supposedly Newtonian cosmology, an ideology of "social individualism" can then appear scientific. Social individualists find it irresistible to co-opt science's authority to justify their ideological stance. In effect, a way of imagining the "out there" justifies the "among us."

The third example of a scientific imaginary is none other than Galileo's theory of heliocentrism. That the earth revolves around the sun would seem to be such a self-evident truth as to be unassailable. In the conventional account, heliocentrism represents a fundamental change in how we view the world, with all sorts of implications for how we should behave towards the world and towards each other. Yet such a worldview belies a subtle conflation akin to that of Russell, one that, on closer inspection, helps to further illustrate how scientific imaginaries work. In spite of our resolute conviction that the earth revolves around the sun, we nevertheless still have the daily, earth-bound experience of the sun revolving around the earth. From where we stand, the sun rises in the East and sets in the West. Obliquely (it's not good to stare for too long), we watch the sun slowly make its arcing journey across the sky.

What we moderns do now, though, *is imagine the earth moving around the sun, and mark that imaginary as the truth, the deeper reality*. That truth bears the authority of consensus over many generations; it is a highly stable knowledge. Most adherents of the heliocentric theory cannot prove its veracity: they accept it as a matter of dogma. We defer to the specialists who, if funded, would gladly conduct (and have conducted as a matter of public record) experiments to verify its truth. In the heliocentric imaginary, the relationship of earth to sun makes use of the geocentricity of common experience. It employs a structure of correspondences between the images (the sun and the planets) and astronomic observation (with the aid of telescopes), but reverses the dynamic and the scale (earth shrinks while sun expands). The heliocentric imaginary also draws upon reinforcing images of earth-images revolving around sun-images, including, but by no means limited to: declarative statements like "the earth revolves around the sun" given by authorities such as primary school science teachers; dioramas with fruit-sized painted styrofoam balls connected by rods and hinges; and graphic illustrations in textbooks or online video simulations.

Galileo used his telescope to observe the Milky Way. He did not recognize it as a galaxy, since at the time there was no basis for comparison between it as an object and similar objects. What Galileo found beyond the Milky Way were fuzzy objects that were clearly not stars. These objects came to be called nebulae. Only later—much later, in the 1920s—with the aid of more powerful telescopes, did Edwin Hubble understand that many of those fuzzy nebulae were actually galaxies. It was only then that galaxies (from the Greek, meaning "milk") became a definitive feature of the known universe. Before then, we lived, with respect to our scientific imaginary, in a world without galaxies.

In our collective cosmology, one imaginary does not merely replace the other. We hold in our mind's eye the daily geocentric experience *and* the heliocentric imaginary, which contradicts while also "clarifying" that experience. Our world has thus become all the more complex and collective, for now we depend on ever more specialists to reveal to us and each other, by means of imaginaries, the various "deeper" realities. This world becomes populated with ever more intricate networks of sometimes complementary, sometimes contradictory imaginaries. Mind you, I am not suggesting that the earth does not, in fact, revolve around the sun—that heliocentrism is just in our head. Rather, our access to the world "out there" is irrevocably mediated by imaginaries. There can be no direct and self-evident apprehension of the world. As a consequence, we perpetually rely on the authority of others to understand the world. And we regulate our interactions with that world accordingly. The myriad and disparate scientific methods may not be faith-based, but belief in one monologic scientific worldview surely is.

As our fourth example, let's return to quantum theory and its effect on the image of the atom. In the late nineteenth and early twentieth centuries, popular culture became fascinated with this startling new science. The atom had previously been understood to embody its etymology—from the Greek, meaning "indivisible" or more literally, "uncuttable." Quantum theory shows that the atom is, in fact, divisible. It consists of a nucleus and an arrangement of particles, electrons, that orbit this nucleus. Based on calculations and collider experiments, the scale of the atom as a whole (10^{-11} meters) and its nucleus (10^{-15} meters) suggest that there exists a vast amount of "empty space" within which electrons "orbit."

At the time, this new way of imagining atoms was understood as the deeper reality. That image shows the atom to be a field of empty space populated with various sparsely situated objects: a tiny nucleus with electrons rushing around it. This image superseded the prevailing image of the atom as a solid, whole, indivisible object. An authoritative knowledge (from physicists) privileged the former imaginary over the latter, often mustering for its reinforcement a higher-order image of surface and depth, where the "deeper" image is the one that is "true." As we imagine ourselves "going into" an atom, the empty space inside it becomes readily apparent.

Again, I am not suggesting that quantum theory is not true—a figment of the imagination. What I am saying is that each imaginary—whether an atom as indivisible object or an atom as field of empty space populated by various objects—is appropriate for a given context. Both describe one aspect of the reality of the world "out there." The actual methods of quantum theory—its mathematics and experiment design—provide prompts for intervention by our bodies with the world. Imaginaries reflect and reinforce those prompts. In a tangible sense, we grope our way blindly through the world with imaginaries serving as visual templates for that groping. Scientific imaginaries are, in effect, *productive* collective hallucinations.

In this collection Joseph Radke has a poem, "Life x 10^{-33}," that expresses this conceit elegantly:

> No, we can't renounce
> the invisible, the fluid foundation
> of the solidly seen. We can
> only imagine and speak
> in shrinking untruths.

Along those lines, consider this: heliocentrism may well be easy enough for a lay person to validate experimentally with the proper guidance and some perspicacity, but what about the existence of quarks—or strings, for that matter?

This collection explores the interplay between culture and nature, between how a community acts in the world and how its members communicate with and come to know each other. It asks us to re-imagine, to quote Serres once again, "our relations among ourselves" in light of "our rapport with things," and in particular, the wondrous new things of string theory. Each piece asks, in its own unique way: as social creatures through and through, just how do we project out into the cosmos our everyday concerns—and how does the cosmos reflect back on those concerns?

Accordingly, perhaps our universe is much more than just "one turn." Perhaps any notion of the universe necessarily involves an intricate folding over and doubling back—a feedback loop. Just as our imagining of the universe influences how we go about our business in this sticky matter of living in the human-scale world, the way we live in community influences how we imagine the universe.

In his Foreword to Lawrence Krauss's *The Physics of Star Trek*, Stephen Hawking observes that "there is a two-way trade between science fiction and science. Science fiction suggests ideas that scientists incorporate into their theories, but sometimes science turns up notions that are stranger than any science fiction." Hawking believes that, apart from being "good fun," science fiction "serves a serious purpose, that of expanding the human imagination."

The "atom smashers" played a pivotal role in putting an end to World War II by helping to invent the atomic bomb. Their success brought with it not only a great deal of prestige, but also political influence, and with that, a huge infusion of cash to the research universities where they worked after the war. In the romance of theoretical physics, the "atom smashers" became a vanguard exploring the frontiers of the cosmos, on both the tiniest and the vastest of scales. As such, physicists have become the *de facto* guardians and spokespersons of the primordial emotional appeal of cosmology.

Nevertheless, Sokal and Bricmont, as purists of the "hard sciences," are quick to point out: "scientific theories are not like novels; in a scientific context […] words have specific meanings, which differ in subtle but crucial ways from their everyday meanings, and which can only be understood within a complex web of theory and experiment." Of course, they warn that scientists are always not entirely innocent in this abuse of science. They may inadvertently encourage "fashionable nonsense":

> [W]ell-known scientists, in their popular writings, often put forward speculative ideas as if they were well-established, or extrapolate their results far beyond the domain where they have been verified. Finally, there is a damaging tendency—exacerbated, no doubt, by the demands of marketing—to see a "radical conceptual revolution" in each innovation. All these factors combined give the educated public a distorted view of scientific activity.

But what can we say about the tempting delectability of string theory imaginaries for we whose business it is to "expand the human imagination"?

I give you the Austrian philosopher Paul Feyerabend's rebuttal of scientific realism:

> Knowledge so conceived is not a series of self-consistent theories that converges towards an ideal view; it is not a gradual approach to truth. It is rather an ever increasing *ocean of mutually incompatible alternatives*, each single theory, each fairy-tale, each myth that is part of the collection forcing the others into greater articulation and all of them contributing, via this process of competition, to the development of our consciousness.

Perhaps realist hardliners ought not to be so automatic in admonishing those who would "distort" science to tell stories about people or to grapple with that great question of our place in the world. My doctoral research focuses on the scientific imaginaries that constitute string theory. The remarkable thing to me is that once you start to look for them, you find these imaginaries popping up in not so obvious places. They're there in the technical discourse, however muted or opaque, just as much as they're there in a poem or a sci-fi short story like the one in this collection by Adam Roberts called "S-Bomb." The story explores, playing off string imagery in fascinating ways, the unraveling of the social fabric.

Perhaps we shouldn't be so quick to dismiss literary treatments of string theory as mere flights of fancy, utterly unmoored from its mathematical truth. Rather let us approach string theory imaginaries as native to many habitats and as such, adapted to those varying habitats. As writers and readers, we can take up strings and branes in our hands, knowing full well that such things come from a place to which they are intricately and precisely fitted, and—with a knowing wink—redeploy these wondrous cosmic objects to places that at first inspection might seem like ill-suited homes. This will nurture within us a more nuanced understanding of the social world in terms of the cosmic, and in turn, a finer understanding of the cosmic in terms of the social.

Colette Inez's poem, "Cosmic Gambol," epitomizes, with a knowing wink, the coupling of a cosmos with an *us*:

> It's a narrow path
> to find my boson mate, elusive Higgs,
> as I desire my *colettions*
> to loop and loop in wavicles
> of joy that make me matter.

Is this coupling not unavoidable, burdened, as we are, with all that relating, so often haphazard, to each other and to things? How pure can science really be? Is it not always laden with feeling—however much hard science purists would try to convince themselves and those in awe of their work that what they offer us is utterly purified of any contaminating human subjectivity?

I'm not saying that the world out there is merely a social construct—a fantasy that we delude ourselves into believing is real. I'm saying that as human beings, we are creatures that filter, and that what is available to us in the form of sensory contact with the universe is severely curtailed by the limits of those senses, which after all, evolved to suit an engagement with the world on human body scales that would best ensure our survival. As I suggested earlier, in some sense, we are blind to the cosmos in all its awesome totality. The sad and humbling fact is that we are only dimly aware of a small fraction of all its glory. (How different the world must appear to a dog, or an ant, or a bacterium.)

I must say that I'm amazed by the startling range of form and expression in this collection—and I hope you will be too. To borrow an expression from Douglas Hofstadter, this collection engenders a kind of "strange loop." It is string theory craning its neck and, turning around, gazing back upon its own form—in all its multiple facets. (Perhaps it is more of a strange hairball or knot—or a many-headed hydra contemplating its own fertile plurality.) Of course, such a collection cannot be exhaustive nor can it pretend to be the final word, only an injection of fresh perspectives from vantage points not necessarily native to the exclusive coterie of working physicists (though, a few of the essays are).

To reiterate, the question on which *Riffing on Strings* pivots is: what can we say and feel about the cosmos we live in through the prism of string theory imaginaries? Rather than just passively consuming science, in accepting its supposed monologic authority, the writers who've contributed to this collection revel in the pluralities of string theory. To quote Feyerabend again:

> [A] uniform "scientific view of the world" may be useful *for people doing science*—it gives them motivation without tying them down. It is like a flag. Though presenting a single pattern it makes people do many different things. However, *it is a disaster for outsiders* (philosophers, fly-by-night mystics, prophets of the New Age). It suggests to them the most narrowminded religious commitment and encourages a similar narrowmindedness on their part.

A string theory imaginary lends itself to analogies with fabric, weaving, unraveling—and to those of music, resonance, and harmony. The writers in this collection implicitly ask, how may we riff on strings? That is, how may we explore the imaginaries inherent in string theory in ways that offer new perspectives on the world we live in, both the social world—the world within our grasp and within earshot—and the vast and enveloping cosmos of which we are a small but significant (at least to us) part? As in music, a meticulous assonance is not always the most moving—often, we long for some dissonance and distortion to complement and highlight our sense of harmony.

I hope that having been inspired by string theory, the pieces in this collection will, in turn, inspire you, the reader, to look upon your world anew. After all, are we not all—at least in some small part—philosophers, fly-by-night mystics, prophets of the New Age? As Jeff P. Jones suggests in his poem in this collection, "Raise It Up in the Mind of Me," a string theory imaginary allows us to "inhabit more space than [we] ought."

I would love to comment here—with all due appreciation—on every piece contained in *Riffing on Strings*. But given the prolixity of this, my introductory disquisition, I've no doubt already tried your patience to its limits. I can only hope I've offered you a few useful keys for decoding the cosmic secrets contained herein.

To be honest, we agonized over the best way to organize the collection. It felt a bit like one of those standardized exam questions where you're asked to "Select the one that is different from the others." You've been told emphatically there's a correct answer, which should be obvious. (Take, for example, this classic IQ test question: Which one of these is least like the other four? A) Horse B) Kangaroo C) Goat D) Deer E) Donkey. Can you think of a good reason to exclude each of them?) Likewise, as we pondered our stack of pieces, we found perfectly valid reasons for sorting them in several different ways. We considered sorting them by: tone, style, thematic affinity, random shuffling, on our own imperfect sense of what we like best, name recognition where writers with bigger reputations go first, or, with a flinging up of the hands, simply editors' caprice. In the end, we decided to organize the collection based on the more prosaic criterion of genre. We start with essays, follow them with short stories, then poetry, and then finish with a complete version of Carole Buggé's remarkable play, *Strings*. We respectfully leave it to the reader to trace her own thread of continuity through this labyrinthine arrangement. By all means, feel free to start at the beginning, turn one page after the other, and finish at the end.

Or, if the spirit moves you, we also encourage you to careen serendipitously from one piece to another…

Notes

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xv "…the so-called Two Cultures…" C.P. Snow, *The Two Cultures and The Scientific Revolution* (Cambridge: Cambridge UP, 1959).
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xix "I'm working on this theory…" Leonard Susskind, *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design* (New York: Little, Brown, 2005) 219.
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xxvii "Even now, one can go to a conference…" Lee Smolin, *Three Roads to Quantum Gravity* (New York: Basic Books, 2001) 181.
xxviii "I realized how much attention…" Lisa Randall, *Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions* (New York: Ecco, 2005) 315.
xxix "The Literal Meaning Theory entails another position…" George Lakoff and Mark Johnson, *More Than Cool Reason: A Field Guide to Poetic Metaphor* (Chicago : U of Chicago Press, 1989) 123.
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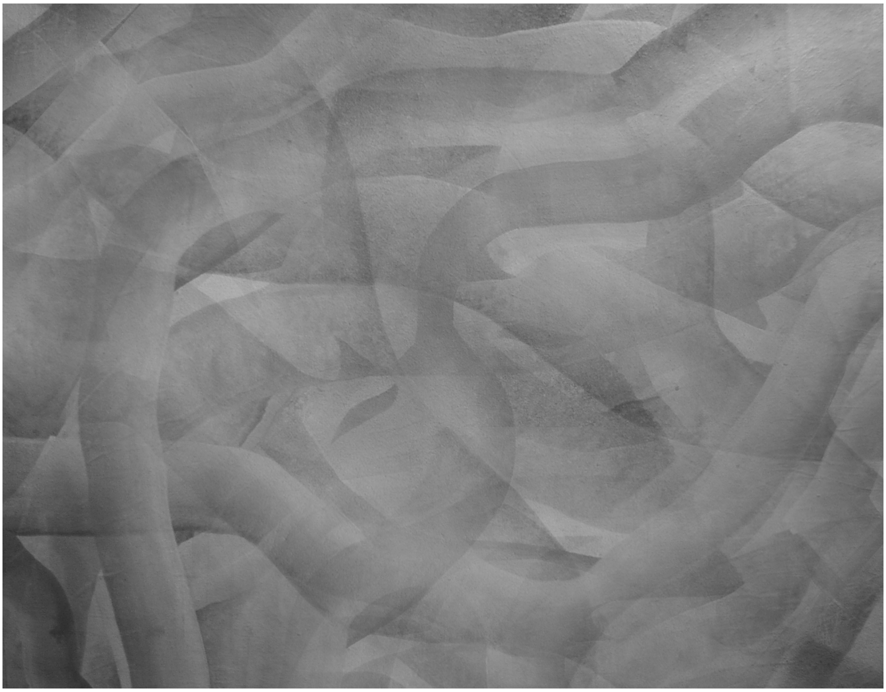
xxxiii "…our relations among ourselves…" Michel Serres and Bruno Latour, *Conversations on Science, Culture, and Time*, trans. Roxanne Lapidus (East Lansing, MI: U. of Michigan Press, 1995) 141.
xxxiii "This object, which we thought…" Serres 148.
xxxiii "…[w]e are just entering a new stage…" Manuel Castells, *The Rise of the Network Society* (Oxford: Blackwell, 1996) 477.
xxxiv "If people were to learn to conceive the world…" Bertrand Russell, *The ABC of Relativity*, 5th rev. ed. (London: Routledge, 1997) 2.
xxxiv "[T]he social development of individualism…" Mary Midgley, *Science and Poetry* (New York: Routledge, 2001) 10.
xxxviii "…there is a two-way trade between science fiction and science…" Stephen Hawking, "Foreward," *The Physics of Star Trek*, by Lawrence Krauss (New York: Basic, 1995) xii, xi.
xxxviii "…scientific theories are not like novels…" Sokal and Bricmont 187.
xxxviii "[W]ell-known scientists, in their popular writings…" Sokal and Bricmont 193.

xxxix "Knowledge so conceived…" Paul Feyerabend, *Against Method* (London: Verso, 1993) 21.
xl "[A] uniform 'scientific view of the world' may be useful…" Feyerabend 250.

Essays



“Superstring” by Félix Sorondo

New Institute at Stanford

Peter Woit

Stanford University will officially announce later today the founding of a new research institute, with major funding from the John Templeton Foundation. Many of the faculty and research staff of the new institute will come from the present Institute for Theoretical Physics, which will be shutting its doors.

Co-directors of the new institute will be Stanford faculty member Leonard Susskind, and Gerald Cleaver, who is currently head of the Early Universe Cosmology and Strings Group at Baylor University. Susskind, who is one of the co-discoverers of string theory, has in recent years been the most prominent promoter of the theory of the "multiverse," which he describes in a recent interview. Later this month he will be giving the Einstein lecture at Brown University on the topic of String Theory and Intelligent Design. He is widely considered to be the leading candidate for next year's Templeton Prize. Cleaver, a prominent string theorist who was a student of John Schwarz (the co-discoverer of superstring theory) at Caltech, has published more than 40 important research articles on string theory. Like Susskind, his recent interests have been in the area of string cosmology.

Next year the institute will open its doors with a year-long program on the topic of the multiverse, led by theoretical cosmologist George F. R. Ellis visiting from the University of Cape Town. Ellis, the 2004 Templeton Prize winner, explains that the traditional view of an opposition between faith and science has been made obsolete by the latest research in string theory and cosmology. Says Ellis, "In the end, belief in a multiverse will always be just that—a matter of belief, based in faith that logical arguments proposed give the correct answer in a situation where direct observational proof is unattainable and the supposed underlying physics is untestable."

The new institute will be named the Stanford Templeton Research Institute for Nature, God, and Science (STRINGS) and will collaborate with other related Bay Area organizations, including Stanford's own KIPAC (Kavli Institute for Particle Astrophysics and Cosmology) and Berkeley's CTNS (Center for Theology and the Natural Sciences). Steve Kahn, the director of KIPAC, welcomed the formation of the new institute, saying, "We're very pleased to have such a major institution on campus led by two such prominent physicists working on cosmology. In this era of declining NSF and DOE budgets, we need to branch out from traditional approaches to science. We expect to collaborate with the new institute to help us seek funding from sources such as the President's FBCI initiative." Besides the physicists, several faculty from other Stanford departments will be affiliated with the Templeton institute, including computer scientist Donald Knuth, author of the recent book *Things a Computer Scientist Rarely Talks About*.

According to Dr. John M. Templeton, Jr., president of the Templeton foundation, "the idea for the institute grew out of our involvement with a series of lectures at Stanford in the area of biology. At those lectures the biologists pointed out to us that it was the physicists on campus who were doing work most closely related to our foundation's interests, something we had already noticed through our Cosmology and Fine-tuning Research Program. As the latest cutting-edge research in physics has caused physicists to rethink what it means for a theory to explain experimental data, the wedge driven by Galileo between science and religion has begun to close. We're very proud to be able to support and encourage this trend."

Encouragement also comes from some other members of the Stanford physics department. Nobel Prize-winning theoretical physicist Robert McLaughlin was quoted as saying "theoretical particle physics is just getting old and losing its youthful good looks. Even Ed Witten has given up on it. This latest plan for the cosmology/multiverse/string theory crowd to join up with Templeton reminds me of a woman deciding to become a nun when she gets too old to attract men. But if it gets them out of the physics department, I'm in favor of it. Don't let the door hit you on the way out, guys."

Fictions

"String theory (vibrating)" by Alex Nodopaka

S-Bomb

Adam Roberts

What does the "S" stand for?

There's a black blotch in the sky where the starlight has been hoovered away. Any northern hemisphere night sky shows it. You'll have heard of this, of course. It can't be a planetary body, although it's round enough for that; but there are no gravitational effects detectable. One theory is that it is a concentration of dust occluding the starlight in a circular patch. There is concern, for the dust seems within the solar-system and therefore close to Earth, but it is below the line of the ecliptic and approaching no closer. There are of course plans to launch probes to examine the phenomenon. It's a question of finding the funding, of working out a launch window, that sort of thing.

**

—I'll tell you what. When they named the A-Bomb, they plugged into a cultural context in which A was the top school grade, and *A-OK* and *A1* had wholly positive associations. Even the word *Atom* connoted focus and potency, think of *the Mighty Atom*. And then, only a few years, the world hears of a *more* powerful bomb, the H-Bomb, and "H" meant nothing, except itself: Hydrogen. It connotes the gaseous, diffuseness, the whiffy. In their *heads* people knew this bomb was more deadly than the former, but in their *hearts* they couldn't truly credit it. So, I guess what I'm saying is, what, really, might people make of S? S-Bomb?

—*Sex-bomb*.

—Wasn't that a song?

—*If it was*?

—When I was a child, there was a pop group called S-Club. Or was it S-Group? But, see, S-Group, no. That sounds more like a secret arm of the military. I can't believe a kid's pop group would go for that sort of name.

—*And when* I *was a child, there was a pop group called the Incredible String Band. So what do you think of that?*

—The Incredible String Bomb?

—*Incredible, after all, is a pretty good word for it. From where I'm sitting I'd say that incredible describes it pretty well.*

—Except—these are no ordinary strings, Super, after all.

—*String bomb sounds like a Wallace and Grommit device. A back garden shed concoction.*

—See, that's my point. S-Bomb is a phrase that lacks the necessary.

—*Or further back? There's the echo of SS. No? The SS-Bomb? Some Nazi artifact. That sounds pretty mean.*

—Better. Better.

—*Also—I mean, you correct me, you're the expert—who calls them super-strings any more? Clumsy and rrropey metaphor.*

—I guess. S for Sub-materialities. S for Severe. Serious, ser, Seriousnesses. Sparks. Sparkles inside everything, and this bomb harnessing that.

—*Except, see if I understand right, not so much* inside *as—*

—Not inside things. No. Constitutive of things. Yes.

—*You do sound—nervy. Do you have something to tell me?*

**

The two of them were sitting in a coffee shop, the Costarbucks Republic, the Coffee Chain, whatever. There were two thicklipped porcelain mugs, large and round as soup bowls, on the table before them. Inside one a disc of blackness sat halfway down, with little pearls of reflected brightness trapped in its meniscus. The other mug was as yet untouched, and brimmed over with a solid froth of white that was dirtied with brown-black like pavement snow.

So much for their *coffees*.

The one man was old, a face like the older Auden, his nose fattened with age, two wide spaced inkdrop eyes. His hair was white and closetrimmed and expressive of the undulating contours of his big old skull. The other man was young, and you might call him handsome if you happen to find male beauty in that block-faced, pineapple-headed muscular type. But he was very nervous indeed; very fidgety, and anxious, and gabbly. Why was he talking about long vanished pop groups and suchlike chatter?

The place was partially occupied, readers and laptop-tappers distributed unevenly amongst the darkwood tables. Behind the counter two slender men, both with skin colored coffee-au-lait, waited for the next customer. It's a neutral place to meet, is the point of it.

**

What's the weather like? Aren't you interested? Look through these wall high plates of carefully washed and polished glass. What can you see?

It's a pretty windy day. The weathermen didn't foresee that. There have been clear-sky gales to the west. A weird turbulence, unspooling tourbillons to the north and the south that resonate into unseasonal storms, flooding, wreckage. Nobody can explain it. But it's only weather.

**

The two men sat in complete silence, the older one staring balefully at the younger, for two minutes. Two minutes is a very long time to sit in silence. Try it. Life is hurry and bustle. People come into the coffee shop and grab cardboard tubes of hot black and rush out. Those cars lurching forward, slowing back, lurching forward, slowing back, all day and every day, such that the tarmac is being continually obscured and revealed.

The moon appears no larger at the top of the skyscraper than it does on the ground. The sun moves through the sky. But it doesn't. It's the sky moves around the sun. That's the truth of it.

The older man sat upright, and his little felt-circle black eyes seem to expand. Those white fur eyebrows, up they go, towards the hairline.

**

—*Run me through again what I am to tell my bosses.*

—Well, sorry, is one thing.

—*We'll take sorry as read. We'll assume it.*

—Obviously we should have been in closer communication with—by we I don't mean *me*, specifically, individually. We're a team, obviously—but, see, I'll be frank, *scientists*, our first reaction is, wait and see. It'll be OK. We think we can sort the problem, present you people with problem and solution in one neat package. Or at least, wait until there's a proper quantity of data before we report anything.

—*You saying there's no solution?*

—No.

—*You're saying the bomb doesn't work?*

—

—*I take your startlement as a yeah.*

—Sorry—sorry—you think that's what I'm here to report?

—*As opposed to?*

—Oh, the bomb works.

—*You're sure?*

—We tested it.

—*You have already tested it?*

—Tested it. It works. Jesus.

—*The people I work for will be pleased to hear that at any rate.*

—What I mean is. Look.

**

You think superstrings are myriad little-little separate strings, one-dimensional extended objects that resonate and shake, that aggregate and disaggregate into subatomic particles, and thence into atoms and molecules and everything in this diverse and frangible world. You think so. Think again. Think *laces*. Think of it this way: one single string, ten-to-the-million meters long, weaving in and out of *our* four dimensions, like laces weaving in and out of cosmic fabric, tying it together. Superstrings is a misnomer. This singular thing, this superstring. The equations require ten dimensions, and we're personally familiar with four dimensions, and all that is true. But when you look at it clearly, there *is* only one dimension. Only the one singularity, the thread that ties all of reality together and also the thread out of which all reality is woven. The one string.

—One string.

—The nature of the technology is that, and the, the *thing* is, said the younger man.

—You're saying you broke it.

—I'm saying, said the younger man, and swallowed air.

The older man lifted his coffee mug, finally, and tucked his white moustache into the white cap of froth.

—S-Bomb, boom-boom, said the younger, and the explosion. Now we were surely not expecting the explosive outgassing, the violent rupture, the A-Bomb thing. But I *was* expecting—I don't know. Maybe sparks, the sparkles, something fizzy.

—None of that?

—Then, said the young man, it detonates. The point is—you're wondering if I'm going to get to the point. The point is, it blows, but not with any explosive detonation. These strings, these threads, these laces stretching, as it were, across ten dimensions, connecting it all together, the whole of reality. Cut them, and, plainly put, our dimensions start to *unweave*, or unspool, or unpick, you choose the *un-* word you like best. It's a baseline reality event. The earth turns away from it. That's not a metaphor. The earth turns; it spins around the sun; it leaves the event behind at the speed of kilometers a second.

—You tested it underground?

—On the contrary. We tested it in the sky. We lifted it up there by a toroid helium balloon. No, no, if you dug it *under* the ground …

—Let's say, interrupted the older man, under Tehran. Under and a little east of Tehran.

—Sure. Then the world itself moves through space, and the effect is to blast out an empty conic up from underneath the city. A hollowness that shoots out, angled and up out of the city and goes into the sky at a tangent, and loses itself in space, the city thereby collapsing into a great mass of rubble. The air, meanwhile, rushing about to fill the vacancy. But it's gone in minutes, because *we all* are travelling at such prodigious speeds, because the world is in orbit about the sun.

—So you're saying that, in effect, the point of detonation of an S-Bomb will appear, from where we're standing, *appear* to hurtle away up into space, said the older man.

—Yeah. Or it might cut a tunnel right through the earth, depending on the world's orientation when it was detonated. Or it might just fly straight up. The earth orbits the sun at about 30 kilometers a second. The sun is moving too, with us in tow, and rushing in a different direction at about 20 kilometers a second. That's a fast sheer vector. It means that the blast *leaves* the world behind pretty rapidly, hurtles above the plane of the ecliptic and away.

—And now you're going to tell me, said the older man, speaking expansively, a voice expressive of confidence, that the vacuum of space *neutralizes* the effect. It just burns itself out up there.

—See, said the younger man, leaning forward, we *wondered* about that. One S-Bomb theory was that, without matter to, to unpick, then it would just put-put and out. But the way it's turned out—no. It's expanding explosively. Faster than any chemical explosion, expanding really very quickly. But not so quickly as we are moving away from it, in our solar and Galactic trajectories, so in that sense we're safe.

—So what's the odds that our planet will swing round on its orbit into this expanding explosion, this time next year?

A weird little trembly high-pitched laugh.

—Man, no. What, the sun, you see. *Is* moving relative to the galaxy. And the galaxy is…anyway, it's a complex spirograph tracery, our passage through spacetime. So we're leaving it pretty far behind us, a spoor of vacuum-vacuum, unstitching the poor fourfold house in which we live. Like the wake of a boat. Or, from its point of view, we're skimming away as it swells.

**

—Now you're sure, said the old man, as he got to his feet, that it's a *real* effect?

—It's real, said the younger man. You know what? I'll level with you. We calculated a forty-sixty possibility that something like this would happen. Something like this. That's why we detonated it high in the air, so that the world would spin us away, day by day, and leave the detonation footprint behind in the vacuum. We figured, it's vacuum! What can happen? But it turns out, more than you'd think.

—So?

—Light propagates across a vacuum. Various electromagnetic radiations propagate across a vacuum. But none of them can propagate across the null space.

—Rubble can?

—What?

—You said, blow it under Tehran, Tehran falls into the hole.

—Well, yes. Because the earth swings away from it, leaves it behind. But, actually, weird things happen to the equations when you shuffle core assumptions about, you know, the fundamental premises of things. Atoms may tumble into null-space, but they get…churned. Or to be more exact: the Earth moves away, into a new baseline, and away from the detonation footprint, and then matter can move into the tunnel dug out by the S-Bomb. But they don't seem to, you know, stick as well as they ought. They seem to slide about more than you might think. But, anyway, at the point of the continuing detonation, *evidently*, electromagnetic waves aren't able to cross the null.

—So, said the older man, who is no fool, the black blotch in the sky. And all the pother in the media.

—And that's going to get worse. Nothing we can do about it. More and more stars are going to get blanked out by the phenomenon, in the northern hemisphere at least, in the backwash of the earth's passage through galactic space. Or actually the sun's, you see what I mean.

—OK, said the general. Long as it stays *out there*.

This is what he was thinking: biggest act of vandalism in human history. He's thinking: but leastways it's not pissing direct into our own pool. And as he extricates himself from the table his military mind is running through possible strategic uses, from attacking orbital platforms to high-altitude bombers, to maybe developing smaller or shorter lived devices that could be used lower down. He can't help thinking that way. He's a soldier.

—I had better go report right now, he said. My bosses will want to know this right away. Then, as an afterthought, *I'll* tell you what the S stands for.

—What?

—Starsucker. Starblotter. Or something (for he's never been very deft with a punchline) about stars. And he was at the door, and looking through the glass into the unseasonably windy weather. Go back to the institute, he said. Go back, and we'll contact you in due course.

**

This string, this one line out of which everything is spun, is broke; and the moment (the infinitesimal fractional moment) when that could have been repaired has long gone. Momentum works in strange ways in ten dimensions. Unspooling, unstitching, unpicking the tapestry of *matter* takes longer than unpicking the tapestry of *vacuum*. They slip free of their weave. The two whipsnapping ends of the superstring are acquiring more and more hyper-momentum. What does the S stand for again? Severed. Say-your-prayers. Stop.

**

Time continues applying its pressure and forcing the other three dimensions along its relentless and irrevocable line. For six months the coffee shop does its regular business, and customers come sluggish and drink and go off joyously agitated. There is a relatively high turnover of serving staff, for the pay is poor and the work onerous, but the two men who served during the conversation reported above are still in post six months on. Six months on is when the whole story breaks to the media: this cornpone country, its tiny research budget, its speculative endeavor, its helium-balloon-detonated-device unsanctioned by any international organization or superpower government. This devastation wreaked on the night sky (for the northern hemisphere night-sky is now a third blotted out by this spreading squid-ink), this hideous destructive power. Worse than atomics. The most massy of mass destructive possibilities. S for shock. Oh, the outrage.

The s-for-shit hits the f-for-fan. The government collapses. The country wilts under the censure of the international community. There's all that.

The whole story comes out. All the members of the eight-strong research team had been holding their peace under the most alarming threats from the security services; as had the dozen or so high-clearance security officials "handling" the case. But one succumbs, and defects, and reveals all; and then, one by one, so do the others. Some scurry up their local equivalents of Harrowdown Hill; some try and tease wealth from the media to tell their unvarnished tales.

For a brief period the coffee shop becomes a place of celebrity pilgrimage: it was in this very establishment, at this very table, that the scientific team first confessed their crime (and this is the term everybody is using now) to a security official. This is where the governmental cover-up began. Journalists, and rubberneckers, and oddballs, swarmed to the shop. The two men who had been on duty that day sold their stories; but their stories didn't amount to very much, and didn't earn them very much money.

But it is the nature of events that they entail consequences over a much longer timescale than people realize. The scientific community remains divided as to whether the unusually severe atmospheric storms are caused by the continuing action of the null-corridor, or whether the null-corridor has long since dissipated, and these storms are merely the long tail of the jolt which the chaotic weather system received from its initial carving.

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And six months after *that*, the shop is empty. The small country that had produced this enormous device has been repudiated by many of the world's nations; there were economic sanctions in place, public shaming. It has offered up dozens of its official personnel, including all the remaining scientists on the team, to public trials and imprisonment.

—*Why were you so secretive? Why didn't you share the theoretical underpinnings of the technology you were developing*?

—We were a small group, working well within the budget for our team. The technology isn't expensive. The most expensive part of our equipment, in fact, was the balloon to lift it up for its trial detonation.

—*But* why *the S-for-Secrecy*?

—We figured we were like the Manhattan Project.

But, no! no! That doesn't wash. That doesn't wash.

—*The Manhattan Project was a wartime project. The secrecy was governmentally sanctioned, and a necessary component of the prosecution of the war. You were working during peacetime. You brought this horror on the world for* no *reason*.

—Not Manhattan Project in the sense of wartime, but Manhattan Project in the sense of knowing that we had a *potentially* catastrophically destructive technology on our hands. The last thing we wanted was for this to leak out. Our secrecy was motivated by a desire to protect humanity from the—

But it's no good. To prison they all go, for the term of their naturals, and the new government, and then the one that comes into power after that falls, makes repeated obeisance to the international community. And although some of its allies stand by it, the sanctions of others do bite. Its economy turns down. People lose their jobs. Poverty increases. It's all bad news.

Another government tumbles, tripped over by this immoveable object, this S-Bomb. Life gets harder still, and fewer and fewer people are in the position to afford frivolities like expensive coffee-shop steam-filtered coffee. The journalists are no longer interested. The ordinary disaster-tourists and rubberneckers don't call by any more. Only the weirdoes keep coming; and here's a truth about weirdoes: they're generally too parsimonious actually to buy the damn coffee. More often than not they come in, sit at The Table and run peculiar home-made Heath-Robinson handheld devices over it, up and down its legs, as if looking for something. Aluminum foil and cardboard and glued-on circuit boards and things like that, wielded as if the table could, if plumbed correctly, *reveal something* about the way an S-Bomb is constructed, or about the fundamental nature of reality, or things along that axis of thought.

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The nations of the world, the ones that excoriate as much as those that stand-by, of course institute their own programs to uncover the technology at the heart of the S-Bomb. And it's not difficult, once you grasp a few general premises. Within the year there are a dozen functioning S-Bombs, none of which are publicly acknowledged. A year after that there are hundreds. There are different modalities and strengths of the device.

Does this sound like a stable situation to you? And yet another year slowly unspirals itself, and another, and another, without the world coming to an end.

The coffee-shop, to stay financially afloat, has rethought its business-plan to concentrate on cheap food, alcohol, and all-night opening. The expensive darkwood fittings and chunky chairs are starting to show wear and tear; and the clientele now mostly consists of people in cheap clothing who buy the cheapest soup on the menu, grab three breadrolls from the breadroll basket (despite the sign that says "*one* bread-roll per soup *please*"), cache two in their coat pockets, and then sit for hours and hours at their laptops trying to scratch together e-work. Thin chance of that, these days, friend. Hard times at the mill. They complain that the heating is turned down too low. The new manager stands firm. From next week, he decides, he's moving the breadroll basket behind the till. Customers will be issued with one roll when they have paid for the soup, no discussion, no argument.

But here's an old friend—looking no older. Close cropped white hair, whorled and scored skin. And with him, looking *much* reduced, the younger guy: thinner, raccoon-eyed, with a timid body language and a tendency to hang his head forward. And a third person: armed, e-tooled up with a head-sieve and fancy shades. The finest private bodyguard money can buy. He gives them privacy; checks out the space; waits by the door.

The two old friends can't sit at *the* table, since it was long since sold on i-Bay, but they buy some coffee and sit at *a* table, and that suits them just fine.

And for a while they simply sit there.

Eventually the younger one, his eyes on the tabletop and his manner subdued says: you taking me back after?

—Consider it your parole.

The younger man digests this fact.

—Not going back?

—No.

—I could tell you my opinion on the Antarctic business, he offers. This whirl-tempest thing. I have been thinking about it.

—We got people on staff who have been offering expert opinions on that.

This seems to pique the young man. I tried to keep up, he says, much as I could, as was possible within the confines of. But my internet access was severely, I mean *severely*, restricted.

—Really. Prison, says the older man. Who'd think it?

—What I'm saying (eyes still on the tabletop) is, I recognize that there will be people who have kept up with all the science better than I've been able.

—You're not out, says the older man, so that we can tap into your scientific expertise. That's not why you're out.

The obvious next question would be: then why am I out? But the young man has got out of the habit of interrogating others. So he just sits there. He keeps looking up at the bodyguard, flicking his eyes at the man's impassive face, stealing glances at the chunk stock of his Glock.

—Here's one thing, says the older man, you'll maybe have seen. Or heard about. The Chinese were trying to splice out a whole section of string. Best as I understand it, it would involve a double cut, liberating a continuous section, with the very rapid gluing-together of the remaining sections before they shot off to space forever at twenty-seven klicks a second. But the liberated section is carried along with us, apparently.

This gets the younger man agitated, although in a semi-contained, rather strangulated manner. See, this talking of splicing is a lie. You can't splice the string. The best you could do would be a temporary field-hold, and the equations include chaotic elements when you try and work out how long the hold is going to last. Not that you could do anything after the fact. If it breaks it'll be millions of kilometers away by the time it does.

He dries up, glances at the dour face of the older man, and then back at the table.

—Anyway, he says, in a gloomy voice. If you cut the string twice you'll *get* a continuous section. You just won't be able to say how long. It loops through ten dimensions, don't forget. It passes through six dimensions we can't even see. It might be a few meters long, or thousands of light years.

—A continuous whole section of that length, says the older man, drily, wouldn't be much use to us.

—But because it loops through so many dimensions…

—You think I don't know all this?

The young man looks up again, alarmed. Then, eyes down, he picks up his coffee and slurps it.

—This is the weave underlying everything, says the older man. We've all become pretty expert in this subject. This is the *ground*, the paper upon which the ink of reality is laid down, against which it is readable. Not only our world, but the whole cosmos, all matter and all vacuum, it all rolls itself along this endless medium; and without this medium it wouldn't exist as cosmos, matter, and vacuum. Everything material is relative, but this—this is absolute.

—I give the world, says the young man, one year. I'm amazed it's lasted as long as it has. This south polar sea incident—that shows you something. That shows you that S-Bombs *will* continue to be detonated. They'll be set off, by governments or terrorists, rogue states and idiots, and each one will knock another hole in the reality upon which we depend. Soon there will be hundreds of loose ends in the superstring. It will unspool more and more rapidly. It'll fray more and more.

—As I say, says the older man. We got brighter and better informed experts working for us now. Brighter than you, and better informed than you.

The younger man takes this in his stride, as how could he not? Seven years of prison are enough to break most people. He even nods.

—Let's say, the older man continues, that the Chinese have achieved this thing. We're not sure if by luck or judgment; but say they cut loose a segment of the unitary superstring. Say they unlaced it from ten dimensions into one dimension. One of ours.

—You mean, two?

—Just length. As breadth- and depthless as it is timeless. Or, let me be more precise. When it's looped about itself, or knotted, then effects of breadth and depth and time and other stuff are measurable. It's the *proximity* of one length of string to another length, and the precise pattern or orientation, of that proximity. One portion lying close alongside another, and you've breadth. Lying alongside another at a different orientation and you've time, and so on.

—They can manipulate it?

—So it seems.

—How? How can they? How?

—Their glue is better than our glue, I guess. They haven't created a discernable breach, for instance, so we think that they've found a way of holding the two severed ends of string in something approximating stability. They're in orbit, by the way, so maybe that helps. But our sources suggest they've got a separated out, whole, workable two-meter piece of string.

—That's very, says the young man, and he means to add, impressive, but the words dry in his throat.

—You know what they've found?

—What?

—The operation of this thing?

—I don't know.

—You couldn't guess. And we're not sure, because this is not first-hand. But by all accounts, the American security services, and ours, because ours depend upon theirs. This is what we've discovered: by manipulating it they manipulate grace.

—Grace.

—Grace, says the old man, and with this third iteration of the word he sits back in his chair and smiles. The curlicue grooves of his face buckle and chew, and his smile grows broader. It is alarming.

—I didn't realize you were religious, mumbles the young man.

—You didn't realize very much, returns the older, placidly, when you started on this project.

The young man looks up from the table, and there's a small flash in his eyes. I didn't, he says, realize I'd end up in prison, for instance.

—So why do you think we've sprung you?

The young man drops his eyes again, and shrinks back into himself, but he replies, in a low voice: I should never have gone to prison. My team were scapegoats. We worked under ministerial license, and carte blanche, on a weapon's program. If it weren't for the cap (which is what the half-sky filling northern hemisphere blackness is now usually called) and the baying-for-blood media, and the ignorance of the public, then…

He stops.

—And anyway what, he asks, do you mean, *grace*? Grace? What's that?

—You know, says the older man, turning his right hand over and back and over as if signaling 'so-so' very slowly, Grace. Beautiful sunsets. That lovely tickle inside your chest on Christmas morning. The tremendous mystery.

—What are you talking about?

The old man sits forward, and his deep wrinkles settle on his face. Oh, he's serious *now*.

—The medium of matter, the medium which enables the plenitude of the material. You know what the S- turned out to stand for? Spirit. That's what we've been dabbling with, cutting and splicing. And the Chinese, by all accounts, have made a machine that includes a one-dimensional stretch of Spirit. And who knows what they can do by manipulating it? Do you think they can kill or heal? Bless or damn? Some of the reports are pretty hard to credit, actually. But it won't stay under wraps for ever. These things never do.

There is a little more color in the young man's face as he looks up.

—You always knew, he says, that we had been specifically tasked with developing an S-Bomb. The orders were sanctioned from the highest levels of government. We were doing what we were told to, up to and including organizing tests. And then, when public opinion went sour, we were the ones hung out to dry. How many of my team are there even *left*?

—Atonement, says the older man. That's why you're out, now. That's what we're preparing for. Sacrifice, atonement. Transgression and forgiveness. We're working on the best information we have. But these are going to be the materials of the new dispensation.

—Whose transgression? says the younger man, sharply. Whose forgiveness?

—Another thing not in the news. A certain…organization…claims to have sunk a working S-Bomb into the Atlantic east of the USA. If they detonate it at the right moment it'll rip at twenty-five kilometers a second right through the world. It'll set off catastrophic earthquake, oceanic storms, it'll froth up atmospheric turbulence such as the world has never seen, before we leave it behind in space. We're in negotiations with them about the sums of money they want not to do this.

The young man is looking at the table again.

—You understand what I mean?

Nothing.

—You think you have suffered? says the older man. You think your sufferings have even *begun*? This discovery, and these weapons, belong to a reality whose laws we understand in only the crudest way. But if its currency is atonement, then who is better placed to offer himself up to that than you? There have never been such dangers of death facing the world. Do you understand the ferocity of what you've done?

—We didn't mean…

—Ask yourself again: why have we brought you out of prison? Why would we? How can you help? In what way can you atone?

The young man stares a long time at the tabletop.

The older man leans forward, and speaks in a rapid, low tone, as if pouring the words directly into the younger man's ear. Listen, he says. Listen to me. It's always been this way with bombs, on the one hand the rocket that hammers cities to powder, on the other the rocket that elevates human beings to the moon. It's always been this way. Your little S-device has polluted a third of the night sky with opacity. Three more have been detonated now, spreading their ink. How could it *not* be the case that, understood properly, this same device will heal?

The young man, eyes down, keeps staring.

**

As they talk, the proprietor sits on a stool behind the reinforced cash register, reading the paper. This is the lead story: experts say S-Bomb death spreading through the universe. This is the gist of the story, in which "cosmological expert Jerry Lowell" is quoted:

> *If the universe were infinitely big and filled with an infinite number of stars, then the night sky would be white, because no matter which direction we looked out our line-of-sight would end, eventually, with a star. There would be interstellar dust, of course, which you might think would occlude the lines of light, but in an infinite universe these would heat up and incandesce. But we don't see a white sky when we look up at night. So perhaps the cosmos is finite.*
>
> *But what if the S-Bomb technology is, like mathematics and nuclear power, something that every civilization discovers in due course? What if there have been millions, or billions, of alien civilizations out there that have discovered the S-Bomb, and detonated them, and left behind billions of slowly expanding spherical blots of impenetrable blackness. What if the dark between the stars that we see when we look up is that…these inevitably unspooling spots of death, growing eventually to devour everything? What if that's the truth of it?*

Another customer, and the proprietor folds the paper away and gets off his stool. A white porcelain mug, and the nozzle squirts black coffee promiscuously. It covers the white circle at the base of the mug almost instantaneously.

A Report on the New String Theory Library

Daniel Hudon

Not long after the Fourth String Theory Revolution, the Institute of Higher Dimensions made plans to house the exponentially-growing collection of string theory papers in a new library. At the insistence of the President of the Institute, who specializes in Kaluza-Klein particles, which travel primarily in other dimensions, the Library Task Force held a competition for the design of the much-anticipated structure. String theorists around the world, unable to keep up with their rapidly changing field, applauded the idea and submitted as many proposals as the leading architects.

A sampling of the submitted suggestions gives some flavor of the proposals:

– it should be symmetrical, "for obvious reasons;"

– it should be modular to allow for expansion;

– it should be tall enough to have a clear view of the surrounding landscape;

– a virtual library would suffice, perhaps in the form of a café that's open twenty-four hours for string theorists to converse;

– all dimensions of the library should be built in integer multiples of the Planck length;

– it should be holographic and impervious to hypothetical particles like tachyons;

– it should be in the shape of a six-dimensional Calabi-Yau manifold;

– it should be beautiful, "like the theory."

Many proposals argued that given the unwieldy amount of literature, the only viable proposals were those that included compactification of manuscripts and storage in higher dimensions.

After the deadline, the Library Task Force (LTF) whittled down the enormous number of proposals by dividing them into three categories:

a) realistic;
b) imaginable;
c) promising.

Proposals that could not be categorized were eliminated. Proposals that fell into multiple categories were ranked more highly and in this way, the winning entry was to be chosen.

However, when the LTF discovered that the number of official proposals, 857, was a prime number, they decided instead to honor all proposals. Rather than constructing a building of astonishing complexity, which suited the potential contractors because of the ongoing slump in the construction sector, the LTF reasoned that it was simply a matter of scaling.

The main collection of the library will be housed in a series of pairs of five-story circular towers connected by an infinite hallway. This tower duality (linked at the first, third, and fifth floors) will contain coupled versions of string theory scrolls (see below) and enable the exploration of the theory's various symmetries. While there has been some concern about how the length of the hallway will affect the time it takes to retrieve individual string theory manuscripts, it is expected that because of the storage benefits this difficulty will eventually be overcome through the creation and duplication of virtual catalogues, and building structures like tunnels and "worldtubes" or, simply, additional entrances.

Construction of the library began immediately after this decision. A chain link fence went up around the Institute's under-used athletic center, a wrecking ball was brought in, earth was moved, and amid the sounds of heavy machinery, the library evolved from imaginary to reality.

With the first stage of construction underway, the LTF shifted its attention to the problem of organizing the library holdings. Because of the nature of string theory, which rewards imaginative multi-dimensional thinking, it was decided that new papers and preprints would be reduced in size and transferred onto scrolls so that as many as six papers could be scanned at once as the scroll was unfurled. Comparison to the great Library of Alexandria was inevitable and intentional.

All nine LTF members agreed on the idea of the scrolls, but how should they be catalogued? Again, several possibilities were considered:

1) randomly;
2) alphabetically by subject or first author;
3) chronologically by submission date;
4) hierarchically, in terms of either degree of difficulty or energy scale of the paper's fundamental axioms;
5) categorically, using mappings and arrows (known respectively as "functors" and "morphisms").

Though the first four possibilities had their merits, the LTF agreed that an organization based on category theory, recently developed by mathematicians, would provide maximum usefulness for the library's collection. In particular, the functors and morphisms, like conceptual facilitators, would allow unforeseen connections to be made between the different papers and possibly lead to novel theoretical developments whose predictions could one day be within reach of today's (or tomorrow's) particle accelerators.

Having put the organization of the collection on solid footing, the LTF next hired its head librarian, Richard Feynman[1] (selected from 75 applicants), formerly the manager of the Institute of Higher Dimensions reading room. In short order, Feynman put his stamp on the position through a series of high-level purchases, including several other libraries. Rumors abound that The Einstein Papers Project, in Pasadena, California, the Stanford library, and all thirty-seven math and physics libraries of the University of California system would be moved to the recently opened library. Funding for these purchases is thought to be coming from government grants, anonymous private donors, and the first fifty years of late fees of library materials.

Other known purchases include first editions of the works of Lewis Carroll, Edwin Abbott's *Flatland*, the complete works of Italo Calvino, Jorge Luis Borges, Stanislaw Lem and the Oulipo writers. Several modern art museum curators have also reported interest in their collections of René Magritte, M. C. Escher and the entire Cubist oeuvre. It is noted that decorating the walls of an infinite hallway is a daunting task.

Though the LTF claims that "great progress" has been made in the construction of the library, no one seems to know how far it is from completion, nor is anyone willing to make a prediction of when it will be fully operational. Despite the ongoing construction (and delays due to scaling problems), the construction fence, whose perimeter had been extended outwards on a near monthly basis, has now been peeled back and the dictum above the great-arched entranceway is clearly visible: "Let None But Geometers Enter Here." Researchers have begun to peruse the curved shelves within the circular towers, borrow materials, collide with each other while pacing up and down the infinite hallway deep in thought, and even write equation-graffiti in the bathrooms. As expected, the most popular place is the Calabi-Yau Café, where impromptu symposia are held during its round-the-clock open hours. Aware that the library has already grown large enough that parts of its collection may never be explored, Feynman shrugged, "String theory is finally getting the home it deserves."

[1] No relation to the Nobel Prize-winning physicist, who died in 1988.

Secrets

Tania Hershman

In one of her extra dimensions Mrs. Sue Lawrence keeps a pair of tights, in another, one of her usual lipsticks in a small case with a mirror, and in a third she has a spare printout of her "Who to call in an emergency" list—headed by her sister rather than Mrs. Lawrence's daughter who is somewhere travelling in India and hasn't been in touch for several months - should she be knocked down by a bus or taken ill in a public place.

Mr. Evan Evans has hidden one cigarette in each of his extra dimensions, which is one more than he is supposed to be smoking and which would cause an almighty row with his wife if she found out he had them, and maybe this time she would actually leave him instead of getting as far as packing a suitcase and then sitting on the edge of the bed and crying until he promised again, trying not to cough, that he'd quit.

No one knows she writes them because Angela Simmonds keeps her poems in one of her extra dimensions, away from her Mum who she's positive goes through Angela's drawers on a regular basis and who wouldn't understand if she read about how down Angela sometimes gets and how she feels about all the stupid giggling idiots who are supposed to be her best friends and who she sometimes imagines hanging by their painted fingernails over the side of a cliff, screaming.

He was supposed to have made it public already but Andrew Bailey's too scared to show anyone his wife's last will and testament because he knows that they'll all think he did it for sure, so he folded it and folded it again and slipped it into an extra dimension, but every day he locks himself in the bathroom at work and gets it out, just to look at the way she signed the bottom in purple pen and her big loopy letters and to touch her handwriting with his fingers.

So that none of his money-grabbing kids and their bloody offspring get their hands on the fortune Ray Goldman worked so hard for he's stuffed his extra dimensions full of notes, nothing in the bank except his pension check, which he uses to keep him stocked in Scotch whisky and spaghetti and to pay the cable bill because if they cut him off from his favorite programs then there's no point going on at all, might as well call it a day.

Mrs. Caroline Evans only uses one of her extra dimensions, and in it is a picture of her from twenty years ago, before the troubles, before she met Evan and before the drowning, and just knowing it's there, that she wasn't always like this, that the world wasn't always a dark and miserable place where beautiful children can suddenly be taken away, makes her feel better and gives her a reason to get out of bed each day.

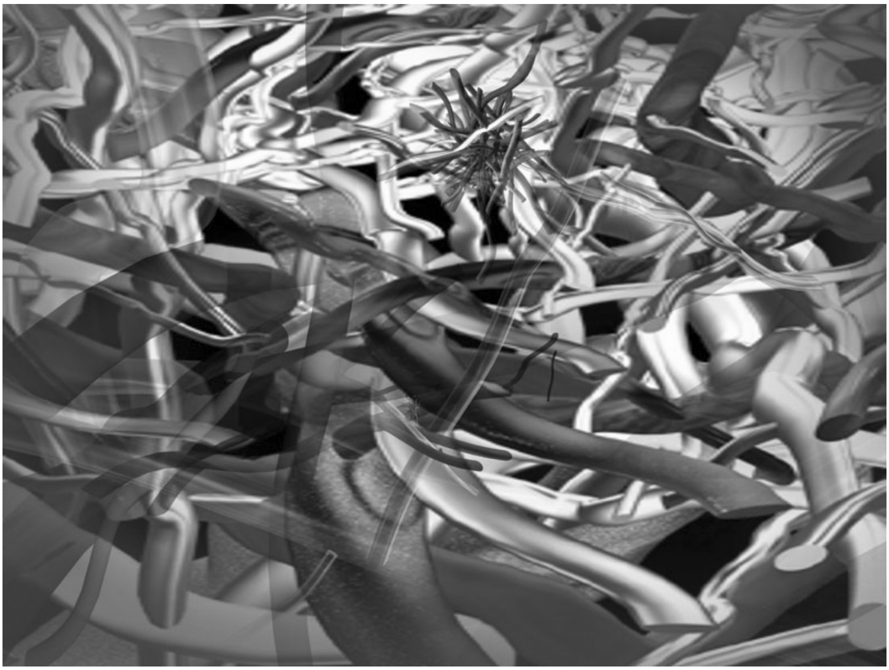
Chief Superintendent Baker has named each of his extra dimensions and in one of them, *Unsolved Murders*, he keeps a picture of Andrew Bailey with two pages of typed notes written by Baker, one page giving his reasons why he is convinced Bailey is guilty, and a second page with all his reasons why Bailey could not have been the killer, and Baker doesn't expect ever to move these notes into his *Closed Case* file.

Marjory Simmonds hasn't looked in any of her extra dimensions in years but if she did she might be surprised to find the pieces of paper she hid in there when she wasn't much older than her daughter is now, and she might smile as she unfolded them and remember how she felt when she sat at night with a torch under her covers and wrote tortured verses about how bleak she felt and how she would never love anyone again, and then she might put the pieces of paper back again and go and make her daughter's favorite dinner, spinach and cream cheese lasagna.

The hospital in Mumbai gave her three pictures of her unborn child and Sonia Lawrence put them in different dimensions, to keep them safe for the days she knows will come when she will want to remember the life she carried inside and then gave away because she was too young, because this wasn't included in any of her future plans, because her mother would never understand.

Sandra Goldman Myers is studying theoretical physics and her doctorate is focusing on the way extra dimensions can be folded and unfolded, but in one of her extra dimensions she keeps the birthday card her grandfather sent her where he wrote, with a fountain pen whose ink was running out, how she was the only one of his grandchildren that he liked and how he hoped she wouldn't turn out like the rest of those good-for-nothings, and when her uncles come to her and demand that she finds a way to get hold of Ray's fortune, she stands up from her desk, looks straight at them, and tells them that if they ever come to the lab again she'll call security.

Poems



“Superstrings 09-03-05 set 32” by Félix Sorondo

Life x 10^{-33}

Joseph Radke

– for JP

No one denies the unseen –
the rush of guardian wings,
the whirl of charmed quarks.
And who could doubt
the supersymmetry of the universe.
We know love and the beloved, forces

and things that matter.
No, we can’t renounce
the invisible, the fluid foundation
of the solidly seen. We can
only imagine and speak
in shrinking untruths.

So it seems God’s faithful
angels have tired of dancing
on pinheads to the horns
of creation and are wracking
their branes to tune
the superstrings
of their harps’ fundamentals.

String Theory

Bruce Holland Rogers

1. The Eleventh Dimension

No one had direct experience of the extra dimensions, so learning about them at age six was difficult even for genetically enhanced superchildren. Child-friendly names were devised. This helped. Children learned that the eleven dimensions were Length, Width, Height, Time, Happy, Sneezy, Dopey, Grumpy, Sleepy, Doc, and…Even with the new names, one dimension was hard to remember. Even for genetically enhanced superchildren, the universe was not without mystery.

2. Recipe for a Theory of Everything

Start with a figurine of turtles stacked one on top of another and an excellent hammer. Smash the turtles. Smash the pieces, and keep smashing. Pound the dust into atoms. Smash the atoms into protons. Keep smashing down to quarks and gluons. You're close to the theory of everything. Pound everything into strings. Keep pounding. After strings, turtles. Pound, pound, pound. Smaller and smaller turtles, all the way down.

3. But Maybe She Just Couldn't Knit

Wanda had been about to defend her superstring dissertation when the universe gave its answer. Broken strings littered the floors of physics departments everywhere. "But they were so pretty!" she cried.

She drank.

Later, she picked herself up. She went to AA meetings. She spun her old strings into yarn, knitted the yarn into a sweater and wore it to a meeting. Everyone who saw it started drinking again.

Ghazal Proof

Sandy Beck

"String Theory" is what Theoretical Physicists are now trying to prove.
Known as "The Theory of Everything"—how can it be possible to prove?

My mother feared my father's medieval sword collection. He taught me to fence
when I was ten, warned me: *someday you might find you'll have a lot to prove.*

Male Bowerbirds compete for females by gathering the brightest trinkets
with which to decorate their nests. Resourcefulness is what they want to prove.

Before young Isaac played his violin for a cohort of white-haired musicians,
he first decided: my genius is a given—not anything I will ever need to prove.

Evelyn relied on the effects of Cocaine and Opium to enhance her orgasms.
To her they were not evidence of womanhood but skills she had to prove.

Beckett weighed one hundred pounds and spoke in a high voice. He dated
ten girls in three months. Do you think he had something to prove?

My friend Gus got out of his physics exam. Disguised, he kidnapped the teacher
and put her on a plane to Paris. To this day, there is still nothing to prove.

astronauts: three excitation modes

David Hurst

(after Ted Berrigan)

i
they can’t admit in the penetrating
klieg glare of television lights
their natural urge to suckle.
twisting in the expanse of space
tethered to a silver colonial phallus
of coldwar passion, they must know
only their orbital speed keeps them
from falling into recurring dreams
of a great mottled blue areola.
they must glance at it and look quickly
away, moistening their lips with guilty tongues
fumbling about in thick sheaths.
surely they wake each day as i do, stiff,
the memory of her swaying breasts just fading.

ii
they can’t admit to penetrating
their moistened lips with guilty tongues.
tethered to a silver ovary, twisting
in a great womb of coldwar passion,
only the memory of a mottled blue areola
prevents their recurring dreams
from glancing into the klieg glare
of television lights. their orbital speed
keeps their thick sheaths from fumbling
into the natural urge to suckle;
they must know, as they glance
and look quickly away,
i wake each day as they do, stiff,
the fading sway of her breasts just a memory.

iii
they can’t admit to tethering
the great just passion of a coldwar
colonial phallus to the
mottled blue areola of space.
only the memory of guilty tongues
prevents the silver expanse of television
from fumbling about in thick sheaths;
they must know their natural urge to suckle
keeps the klieg glare of lights
glancing quickly away. their moist lips
dream of the orbital speed of ovaries
and the recurring penetration of memory.
surely, as stiff as i each day in the fading
of the sway of her breasts, they must wake.

Raise It Up in the Mind of Me: One Poem, Eleven[1] Footnotes[2]

Jeff P. Jones

Women have small taste for the sea.[3] – Melville[4]

But there's that overnight ferry[5] between Stockholm and Helsinki
she took by herself. Tucked into a sleeping bag against the cold wind,
the hum of giant engines at her back, she saw a shattered burst of light,[6]

red and white and gold[7] crawling across the night sky. She pulls
another shot of espresso, glances at the gray snow[8]
falling and the mediocrity-worshiping world. If she moved

further west, even Portland or Seattle, she would be closer.
Snow in this land-locked place brings a special anxiety.[9]
Each layer a covering. Unstoppable. Inevitable.

It's beginning to stick, and the boy[10] who makes love to her
will soon step through the door and knock snow from his coat.
He'll look up and with a smile breaking his face say, Hey.[11]

[1] String theory posits up to eleven dimensions. This goes beyond high school trigonometry. At least one of these dimensions blurs at the speed of a plucked guitar string, becomes uniformly invisible and able to inhabit more space than it ought.
[2] This poem was originally titled "The Special Anxiety Brought By Snow."
[3] It takes twelve seconds to handwrite this line.
[4] Another three for this one.
[5] Screen is black. We HEAR a woman's voice. We can sense her compassion, her deep emotional reservoir.
[6] In southern Colorado there are rocks that catch fire when struck by lightning.
[7] Golden bits of titanium carved from the shoulder of a Russian satellite.
[8] Picture here a duck's body, egg-white, loose as a fallen tree branch, somersaulting through the water.
[9] Me at my most neurotic: Please don't think of me as a ghost. I myself am afraid of ghosts because they don't like me, they laugh at me, they hate me, they think I'm stupid, they see right through me.
[10] Dale Evers could have been a glam-cowboy success in the tradition of Roy Rogers and Gene Autry. On one shoot, the whole cast was bused out to a desert location. Dale was miffed. Yet a young Indian woman caught his eye and he chatted her up. She'll make this week worth my while, he thought.
[11] Some people believe that sound never dies but continues to reverberate. A conversation from twenty years ago might still be in this room, bounding off the walls. I want to believe this.

Confessions Of Gaver Immer

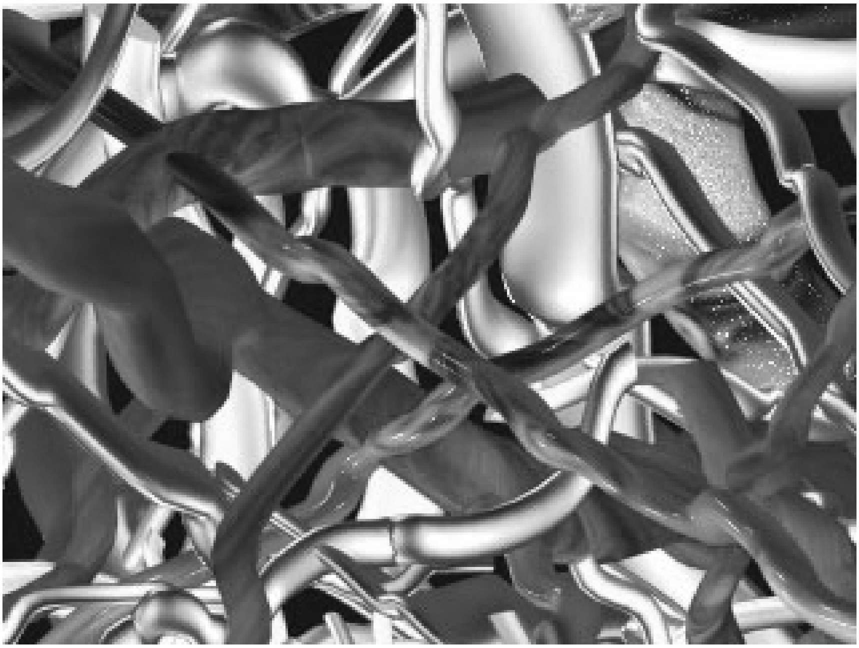
Susan Zwinger

I am awkward on land, a body thrust forward,
tennis is impossible. In higher realms,
I could never keep up with the terns.
Sheer strength carries me thousands of miles,
north over land, south over sea.

I skulk checkered in shadows.
No one but Grandmother Immer
understands me, she gives me
her heirloom pearls for my elegant neck
to be worn to interviews. A checkered
career stalls out. I hover in a poet's
gloamwater light nesting on floating islands.

My echoing tremolo across dawn lake
freezes people in their tracks with longing.
They spin around to catch sight, but I'm under
swimming the eleven strings
of a space they never will enter,
through eleven curled membranes
they can never imagine.

Drama



"Superstrings 26-12-04 set 22" by Félix Sorondo

Strings

Carole Buggé

Cast

JUNE	40's.	Slim, fit, a rock climber, a cosmologist. American.
GEORGE	40's - 50's.	Absent-minded, idealistic, a bit remote. Also a cosmologist. English, upper class.
RORY	40's.	A math whiz, but somewhat childlike and insecure because of his lower middle class background. English. A particle physicist.
ISAAC NEWTON	50's.	Tall and imposing, dressed in 17th century garb. Brilliant and arrogant. English.
MARIE CURIE	40's.	Small, with short dark hair. Dressed in 19th century garb. Quiet, dignified, gracious. French accent.
MAX PLANCK	40's.	Slight, balding, mustache, delicate features. A sweet man, in spite of a certain old-fashioned formality. Prussian accent.

Production note: Though Rory and Planck do play cello and piano in one scene, it is not necessary that the actors are actually able to play—nor are a real cello or piano necessary. In the New York production, they simply sat at imaginary "instruments" and froze in position while a recording played in the background during the scene that followed.

Setting

On board a train from Cambridge to London. The year is 2002.

Act One

(Rory and June are standing on a train platform. Rory looks around nervously.)

RORY: Where is he? The train leaves in ten minutes.

JUNE: I guess he's late.

RORY: He's always bloody late.

JUNE: That's not true.

RORY: Why are you always defending him?

JUNE: I'm not.

RORY: I just wish you could see him as others see him, that's all.

JUNE: I just said that he's not always late.

RORY: Remember the Seattle conference last year? He missed his flight and his lecture on particle radiation had to be postponed until the next day.

JUNE: He had the stomach flu.

RORY: See, that's just what I mean—you're defending him again!

JUNE: What's the matter—are you jealous?

RORY: That's ridiculous.

JUNE: You're jealous.

RORY: How could I be jealous of your husband?

JUNE: Because you're my lover.

RORY: Exactly! He's the one who should be bloody jealous.

JUNE: And yet amazingly, he's not.

RORY: Does he know about us?

JUNE: I don't know. But he wouldn't be jealous if he did.

RORY: Why not?

JUNE: Because he doesn't get jealous.

RORY: That's ridiculous. Everyone bloody gets jealous.

JUNE: You say "bloody" a lot, you know that?

RORY: (with a Cockney accent) That's because I'm bloody working class, ducky. Oh, for Christ's sake, June. What do you mean he doesn't get jealous? Isn't he human?

JUNE: Not quite—no.

RORY: Or maybe it's just too common to get jealous. God knows, George is anything but "common"!

(George enters.)

GEORGE: Hello—sorry I'm late.

JUNE: Hello, darling.

GEORGE: Hello. Hello, Rory.

RORY: Hello, George. We were just talking about last year when you missed your flight to Seattle.

GEORGE: Ah, yes—the stomach virus.

RORY: We were afraid you were going to miss the train. It's almost time for it to leave.

GEORGE: Time is relative, old man.

JUNE: Try telling that to British Rails.

GEORGE: Ten dimensions of space but only one of time.

RORY: What?

GEORGE: M-theory. It's your theory, old man.

RORY: Well, it's not mine, actually; Ed Witten is the one who came up with—

JUNE: We should get on the train.

RORY: Ladies first.

JUNE: If I see a lady around here I'll let you know.

GEORGE: *Touché*, old man.

(They get on the train. The men follow June as she looks for an empty carriage.)

JUNE: This one all right?

GEORGE: Perfectly fine, darling. Whatever you like.

(They sit.)

JUNE: You know, George, there's such a thing as being too agreeable.

GEORGE: Good heavens. (to RORY) Did you ever hear anything like it?

RORY: Women, old man. Best not to try to figure them out. Implicit ignorance—not enough data to go on.

GEORGE: Quite right. (to JUNE) I'm not going to even try to figure you out.

(Pause. There is the sound of a train whistle, and a slight jerk as the train begins to move.)

RORY: I'm glad we were able to get tickets to this play.

JUNE: Yes—it's good to get away from the conference for a while. (Pause. She looks out the window.) Look at the hedges just zipping by.

GEORGE: (to himself) "These hedge-rows, hardly hedge-rows, little lines / Of sportive wood run wild…"

JUNE: What's that, darling?

GEORGE: Wordsworth. "Tintern Abbey."

RORY: George was always rather keen on poetry, even at Cambridge.

JUNE: Ah—even at Cambridge? My goodness.

RORY: I'm not implying that there was no poetry at Cambridge, mind you, but there were…other things.

JUNE: Such as?

RORY: Well…girls—uh, women.

JUNE: So I've heard.

GEORGE: And rugby.

RORY: Ah, yes—rugby.

GEORGE: And rugby women.

RORY: Yes.

JUNE: Women who played rugby?

RORY: Yes…and just women. Those were the days—eh, Georgie?

GEORGE: Yes, indeed—those were the days. (to June) And did you know that Rory was there on full scholarship?

RORY: There's no need to go into that.

JUNE: I'm very impressed.

GEORGE: So you should be. It's nothing to be ashamed of, old man—just because your family couldn't afford to send you—

RORY: Really, George—

JUNE: I agree, Rory—just because George was born into money and you weren't—

RORY: He was also born into the aristocracy, which I decidedly was *not*.

JUNE: If I were you I'd be proud, not ashamed.

RORY: That's because you're not English.

JUNE: I think the English obsession with class is just silly.

GEORGE: That's because you're not English.

JUNE: So *what* if George's family has a title?

RORY: And a castle in Scotland.

JUNE: And a castle in Scotland—so what?

RORY: So what? So everything.

GEORGE: June's right—you should be proud of your accomplishments, old boy. After all, you got a first at Cambridge, whereas I only got a second.

JUNE: I'm surprised you had any time to study at all.

GEORGE: Oh, Rory never studied. He's naturally brilliant.

RORY: It all seems like so long ago.

GEORGE: (to himself) "I grow old…I grow old…I shall wear the bottoms of my trousers rolled."

JUNE: What's that, George?

GEORGE: That is Eliot. As in T.S.

JUNE: Let's not get glum, all right, darling? (to Rory) It's a bad sign when he starts quoting Eliot. Say something to cheer us up, will you?

RORY: All right…right: I've got a joke for you. How many physicists does it take to screw in a light bulb?

GEORGE: (to Rory) I don't know.

RORY: Well, it depends.

GEORGE: On what?

RORY: On whether the light is a particle or a wave.

JUNE: (laughing) Oh, that's a good one.

GEORGE: So how many if it's a particle?

RORY: That's it—that's the joke.

GEORGE: Oh. I see.

(There is an awkward pause.)

RORY: I'm curious to see what this chap is on about. What's his name again, the playwright?

GEORGE: Frayn.

JUNE: Michael Frayn.

RORY: Isn't he the chap that wrote that farce—what's it called?

JUNE: *Noises Off*.

RORY: Right. A bit odd, changing horses in midstream.

JUNE: What do you mean?

RORY: Well, first he's writing frothy little farces, you know, and now he's written this play about physics. That's a far cry from a bunch of birds running around in their knickers. So what's this one about, exactly? What's it called?

JUNE: *Copenhagen*.

RORY: Right.

GEORGE: It's historical.

JUNE: It may be historical, depending on whether he got it right or not.

GEORGE: In any case, the play deals with historical subjects: World War II, physics, the development of the bomb.

RORY: Sounds a bit dodgey to me. I mean, writing about an event that really happened—seems to me you're just setting yourself up for failure.

JUNE: An event that may have happened.

RORY: What do you mean?

GEORGE: A meeting between Werner Heisenberg and Niels Bohr in Copenhagen—

JUNE: Which may or may not have happened.

RORY: That's just silly. It either happened or it didn't.

GEORGE: Uncertainly Principle, old man.

RORY: What?

GEORGE: Heisenberg's Uncertainty Principle—

RORY: I know who bloody Heisenberg was!

JUNE: The play uses that to examine a meeting that may or may not have taken place—

GEORGE: The meeting actually *did* take place. What is uncertain is whether or not Heisenberg deliberately sabotaged the Nazi effort to build an atomic bomb. That's where the connection to Heisenberg's principle comes in—

RORY: Uncertainty only applies to quantum events, which take place on the subatomic level. People aren't atoms.

JUNE: I think it sounds clever.

RORY: Sounds a bit limp-wristed to me.

GEORGE: You don't have to go, old man.

RORY: Oh, no—I'm going all right.

JUNE: What if people *are* like atoms, though? I mean, more than we think?

GEORGE: How so?

JUNE: Well, aren't people as mysterious as the forces in an atom, in their own way?

GEORGE: You mean what if we have more in common with quarks and neutrinos and muons than we think?

JUNE: Yes, something like that.

RORY: I've always felt if I could be any particle I'd be a proton. Positive charge and all that. Also, protons live forever.

GEORGE: As far as we know.

JUNE: What about you, George?

RORY: Oh, George is definitely a neutron.

GEORGE: Am I?

JUNE: Oh, yes. Rory is right.

GEORGE: Why is that?

JUNE: Because you're so neutral about everything.

RORY: What about you, June? What would you be?

JUNE: Maybe I'd be an electron being shared by a couple of big, strong atoms.

RORY: That's a titillating thought.

(George looks at him suspiciously.)

GEORGE: Don't titillate too much, old man.

JUNE: I'm dying for a cup of tea.

RORY: How very British of you.

GEORGE: (to RORY) I sometimes think she's more English than I am.

JUNE: That would be impossible, darling. Anyone else?

RORY: I'll take mine with milk and sugar, please.

JUNE: Right. George?

GEORGE: None for me right now, darling, thank you.

(She leaves. There is a moment of awkward silence between the men.)

GEORGE: I quite enjoyed your lecture on M-theory.

RORY: Oh, thank you. Thanks very much.

GEORGE: I mean it. I found it—stimulating. Not my sort of thing, you know, but—

RORY: What do you mean "not your sort of thing"?

GEORGE: Well, it's not my area of expertise, is it?

RORY: No, I suppose not.

GEORGE: And it's all just speculation, anyway.

RORY: What's that supposed to mean?

GEORGE: Well, I mean, it's all highly speculative, isn't it? You could be right, or you could be whistling through a straw up your ass. No one would know the difference.

RORY: A straw up my ass? What on earth does that mean?

GEORGE: It's just an expression.

RORY: I never heard it before.

GEORGE: You didn't grow up in Kent.

RORY: Neither did you.

(June enters with tea. She hands one to Rory and sits down with hers.)

GEORGE: That was quick.

JUNE: The dining car was empty.

GEORGE: Maybe we're the only ones on the train.

RORY: June, did you ever hear the expression "a straw up your ass"?

GEORGE: That's whistling through a straw up your ass.

JUNE: No. But then I'm a Yank, as you're both so fond of pointing out. We don't have the same finely tuned sense of scatological humor as you Brits.

RORY: Scatologic—

GEORGE: Potty jokes.

RORY: Oh, you think we like potty humor more than you?

JUNE: Definitely. Must be the public schools. All those adolescent boys living in close quarters…

GEORGE: Yes—ours is a deeply wonky society.

RORY: (to George) M-theory is no less reasonable than string theory. In fact—

JUNE: Do you think there's even a remote probability that we could all just enjoy this train ride?

GEORGE: I don't know, darling—probability is more your area.

JUNE: *Touché*, George. What a witty comeback.

RORY: Yes, he should have been a bloody stand-up comic.

JUNE: (looking out the window) This train is really moving.

RORY: Maybe it's the earth that's moving.

GEORGE: That's what June said last night.

JUNE: Maybe it was the train moving last night after all.

GEORGE: No, that was actually the Big Bang.

RORY: Very funny, both of you. (to George) So what exactly is your problem with M-theory?

GEORGE: First of all, why do you call it M-theory? That's so irritating. Why not just call it Membrane theory?

RORY: You'd have to ask Ed Witten. He's the one who came up with it.

JUNE: A lot of people say he's the greatest physicist since Einstein.

GEORGE: But even Einstein couldn't solve the problem of the singularity at the Big Bang—

JUNE: The way the laws of physics break down at that moment.

RORY: I wonder what it's like to be that smart.

JUNE: Oh, come on, Rory—you got a scholarship to Cambridge, for God's sake! You're smarter than either George or me.

GEORGE: I beg your pardon.

RORY: Still, to have discovered M-theory…

JUNE: If you could be any physicist from history, who would you be?

GEORGE: Dead or alive?

JUNE: Either one.

RORY: Like Schrödinger's cat—both dead and alive.

GEORGE: Isaac Newton.

JUNE: That's boring.

GEORGE: He was like Columbus! Nobody knew anything before he came along.

JUNE: Except Galileo.

GEORGE: He wasn't the mathematician Newton was.

RORY: Newton was also an arrogant ass.

GEORGE: He was the Father of Physics. He had a right to be arrogant.

RORY: Did he tell you that himself?

GEORGE: Maybe. What if he did?

JUNE: What about you, Rory? Who would you be?

RORY: Max Planck. I've always wanted to be Max Planck. Not Heisenberg, with his messy uncertainty, but Planck…to discover something like the Planck Constant. (Dreamily) The Planck Constant…the birth of Quantum Physics.

GEORGE: What about you, darling?

JUNE: That's easy. Marie Curie.

GEORGE: Because she was a woman?

JUNE: No, because she was heroic. They both were, Marie and Pierre, but she carried on after his death. Even though she knew she was being slowly poisoned by uranium, it didn't stop her from doing her work.

RORY: There is something noble about her, and something magical about her relationship with Pierre.

JUNE: Hey—I overheard someone at the conference say that the M in M-theory actually stands for "magic."

GEORGE: Or madness.

JUNE: Mystery.

GEORGE: Matrix.

JUNE: Mother.

GEORGE: The Mother of All Theories.

RORY: Call it whatever you want. What's your problem with it? My equations were all solid.

GEORGE: As far as we know.

RORY: What's that supposed to mean?

GEORGE: You still haven't solved the problem of the Big Bang – what exactly banged, and why. But your equations are very elegant. I think we all agree you're a superior mathematician.

JUNE: Well, he is a particle physicist—they *are* the math whizzes, after all.

GEORGE: That's true. We cosmologists can't hold a candle to your—

RORY: Oh, come off it, George! You're a string theorist, for god's sake! We both know the math in string theory is devilish wicked.

GEORGE: Oh, but M-theory is so trendy just now; it's the Next Big Thing. What a charming concept: all matter sitting on these subatomic membranes floating around like giant bedsheets. And we're sort of like fleas hitching a ride, clinging on for dear life.

RORY: Well, string theory *is* getting a bit tired, isn't it? I mean, you string theorists are all—forgive me—rather tied up in contradicting theories.

JUNE: (singing) Fermions, bosons, all tied up in strings—

RORY: (singing) These are a few of my favorite things.

JUNE: (singing) Neutrinos in spandex and quarks in white dresses—

RORY: (singing) Hadrons colliding and making big messes—

JUNE: (singing) Leptons and mesons in tight little rings—

BOTH: (singing) These are a few of my favorite things.

GEORGE: Very funny, both of you.

RORY: I don't see that M-theory is any more speculative than string theory—for god's sake, you string theorists can't even agree with each other! How many competing theories are there now—six, seven?

GEORGE: Five.

RORY: Five!

GEORGE: Competing theories help build knowledge.

RORY: But *five* competing theories? And they say three's a crowd.

JUNE: Oh, I don't know…it takes three quarks to make a proton or neutron—

GEORGE: "Three quarks for Muster Mark."

(Rory stares at him.)

GEORGE: James Joyce—*Finnegans Wake*.

JUNE: And you need an electron, proton and neutron to make up an atom—

GEORGE: And three to make a triangle. Quite a stable geometric shape, a triangle…

(There is an uncomfortable pause.)

RORY: I think I'll go out for a stroll.

(He leaves.)

JUNE: What's wrong with Rory? Have you been baiting him again?

GEORGE: I just mentioned that M-theory was in the early stages yet.

JUNE: Oh George, you know how sensitive he is.

GEORGE: Why does Rory get to be the "sensitive" one? Why don't I get to be sensitive?

JUNE: Because you're not. You're a rock, hewn in granite—a big, solid boulder. Level-headed, sensible—but not sensitive.

GEORGE: It's not fair.

JUNE: Well, darling, life isn't fair. You should have married a nice girl, but you're stuck with me.

(Pause.)

GEORGE: June?

JUNE: Yes, George?

GEORGE: Do you…do you remember that one rainy weekend in New York, when we were living in Hell's Kitchen—when we seemed to be a universe unto ourselves? The world began and ended with the four walls of that apartment.

JUNE: We never left those three rooms all weekend.

GEORGE: And life never felt so complete, so—full as it did that weekend.

JUNE: I remember.

GEORGE: It was as though we had created our very own dimension in space-time…like we had found something fundamental, and were part of a great universal experience. It was like…physics.

JUNE: You read me poetry.

GEORGE: Yeats, Coleridge, Rilke…and I never felt the need for other people. Did you feel that too? Or was it just me?

JUNE: I remember.

GEORGE: I've actually tried to forget, but I remember.

JUNE: Why would you try to forget?

(Rory enters.)

RORY: Am I interrupting something?

GEORGE: No.

RORY: Did you know that the penis of a humpback whale is twelve feet long?

GEORGE: Good God, Rory.

JUNE: What made you think of that?

RORY: I just saw this big hill out the window, and it reminded me of a humpback whale. And I remembered I had seen this special on the Science Channel about whales…(to George) so if you laid us end to end, we still wouldn't be as long as the penis of a humpback whale.

GEORGE: All right, Rory—I get it.

RORY: You're cranky. (to June) Why is he so cranky?

JUNE: He missed his nap time.

RORY: Oh, we missed our nappies, did we?

GEORGE: Don't push your luck, old man.

RORY: My luck is the last thing I'd be likely to push.

JUNE: Oh, speaking of nappies, I understand your sister is having a baby!

GEORGE: I always said that woman was a breeder.

JUNE: George! (to Rory) I'm so glad for her. I'm sure she'll be a wonderful mother.

RORY: Yes, no doubt…

JUNE: Do you…

RORY: What?

JUNE: Do you ever think about having children?

RORY: I'd have to get married first.

GEORGE: Take my advice, old boy—don't.

RORY: I was in the library one day last fall, and there was this tiny girl—I don't know how old she was—three, four? – a perfect human being in miniature. She was struggling with an enormous pink backpack that was almost as big as she was. Her mother was across the room, putting some books back on the shelves. I stopped to help her, and as I caught sight of these tiny, perfect hands I was suddenly overcome by longing—an actual physical ache, the kind you feel when you're in love. I felt light-headed with this untidy jumble of emotions—happy and sad all at once. It was like a fireworks of chemicals in my brain had been triggered by some ancient, instinctive receptors. I wanted to throw a protective web around her and keep her from all things bad and harmful in the world. I don't remember her face – I suppose it was pretty; most children that age are pretty—but I'll never forget those incredible tiny hands. I knew then what mothers feel…it's fierce and powerful and frightening.

GEORGE: So then what happened?

RORY: I helped her on with the backpack, her mother smiled at me, and off they went.

GEORGE: That's it?

RORY: What do you mean?

GEORGE: You didn't kidnap her or anything?

RORY: Why would I do that?

GEORGE: That's a disappointing ending.

RORY: (to June) Do you think it's disappointing?

JUNE: (to George) What *is* it with you?

GEORGE: I'm a man! I want simple, action-filled stories.

JUNE: I have more testosterone than the two of you combined.

RORY: She has a point, old man.

GEORGE: That's ridiculous!

RORY: She is a rock climber, old man.

GEORGE: Your rock climbing is rather ironic, don't you think, considering your breakthrough theory on why gravity is so weak.

JUNE: It may be the weakest of the four forces, but it sure doesn't feel that way when you're scaling El Capitan.

GEORGE: What's the fun in it?

JUNE: I feel like I'm experiencing and defying gravity all at the same time.

GEORGE: But it looks so—tedious.

JUNE: It's not about the progress—it's about the process.

RORY: What do you like about it?

JUNE: What do you like about playing music?

RORY: It's…a conversation. Between me and the composer – and between me and the other musicians.

JUNE: Rock climbing is a conversation with the rock.

GEORGE: Really, darling, that is a bit—

JUNE: There's an abstract beauty about the way the crags join together…it's like the beauty of mathematics.

RORY: But it's so dangerous.

JUNE: And it forces me to be totally in the moment. Time doesn't exist—there's only now. No past, no future. I don't ruminate or plan—I can't afford to.

RORY: And you like that?

JUNE: I can leave my life behind and just be a part of the rocks.

RORY: Is your life so terrible that you want to leave it behind?

JUNE: No, but it's confining and confusing and petty and…human. I like being part of something larger, to just be a speck of flesh and bones crawling up this huge mountainside.

GEORGE: That actually sounds disturbing.

JUNE: I feel like I want to—to know the rock itself. Each rock invites me to solve the puzzle of how to climb it, only I'm solving the puzzle with my whole body, not just my mind. On a really good day, I blend into the mountain—I become the rocks.

GEORGE: This is getting a bit too strange for me.

JUNE: But we're all made of the same material as the rocks, more or less.

RORY: Yes, that's what M-theory is on about, you see! Everything—music, flowers, sunsets, the mystery of love, the whole range of bloody "meaningful" clichés of beauty and truth—it's all getting at that, the center of things, the fact that we're all part of this—this—

JUNE: Membrane.

GEORGE: Waving around in subatomic space.

RORY: Yes. I read your paper, June—I thought it was quite brilliant, the idea that gravity is leaking into our universe from a parallel one. It dovetails so well with M-theory—

GEORGE: So if you M-theorists are right, then there are parallel universes tucked away in between ours—

JUNE: Even Emmanuel Kant proposed the existence of parallel planes, which he called "separate worlds."

RORY: There may be a universe in which June is married to me, for example, instead of you.

GEORGE: In your dreams!

JUNE: And there may be a universe somewhere, floating on a membrane just next to ours, in which the Twin Towers never fell, and David and I are seated at Windows on the World having breakfast looking out at the bluest September sky I can remember.

(George looks at her, obviously stung.)

JUNE: I'm sorry. That was wrong of me, to bring that up. I'm sorry.

(George is still silent.)

JUNE: George? I'm sorry. George?

GEORGE: Let's just *forget* it, all right? (Pause) I think I'll go out for a little air.

(George leaves. There is a pause.)

RORY: I think he knows.

JUNE: What?

RORY: About us.

JUNE: Don't be paranoid.

RORY: I'm not. I really think he knows.

JUNE: Why do you say that?

RORY: He's being so passive/aggressive.

JUNE: That's just George.

RORY: You saw the way he was coming at me about M-theory.

JUNE: He was just being playful.

RORY: He was making fun of me.

JUNE: He respects you.

RORY: Really? You think so?

JUNE: Do you think I could sleep with you if my husband didn't respect you?

(George enters.)

GEORGE: It was wrong of me to walk out like that. I—I should have been bigger than that. (to June) I'm sorry.

JUNE: It's all right, George. I'm sorry I'm brought it up.

(Pause.)

JUNE: Christ, I need a cigarette.

RORY: I thought you quit.

JUNE: I did. I'll have to go borrow one from someone.

(She leaves. Pause.)

RORY: She didn't mean anything by it, you know.

GEORGE: She's still struggling with David's death. I know that.

RORY: I can't imagine what it was like for the two of you to lose your only child like that—

GEORGE: Why don't we just drop it, all right?

RORY: Why aren't you struggling with it like she is?

GEORGE: It was God's will.

RORY: If you don't mind my asking, how do you reconcile your faith with—

GEORGE: With what?

RORY: With being a scientist?

GEORGE: I don't see a conflict. Even Einstein said, "God does not play dice."

RORY: He was speaking metaphorically.

GEORGE: How do you know?

RORY: Einstein wasn't a Catholic.

GEORGE: No, but he was a Jew. Same thing—both are quite keen on guilt.

RORY: Why do you need religion when you have science?

GEORGE: I don't *need* religion; I just happen to believe.

RORY: What do you find so compelling about Catholicism?

GEORGE: I like the incense.

RORY: Seriously.

GEORGE: You sound envious.

RORY: Maybe I am.

GEORGE: I like the Holy Trinity.

RORY: The Father, the Son, and the—what exactly is the Holy Ghost?

GEORGE: I once asked my mother that and she said it was kind of like Father Christmas.

RORY: You mean the Holy Ghost brings presents to good little Catholics?

GEORGE: No, more like it was the spirit of Christmas was not about the presents, but the spirit of giving and all that.

RORY: That doesn't mean much to a five year old who really wants a fire truck.

GEORGE: Speaking of which, there's a question I've been wanting to ask you.

RORY: Go ahead—shoot.

GEORGE: That's an unfortunate choice of words.

RORY: Why? What's the question?

GEORGE: I wanted to ask you if you've enjoyed sleeping with my wife…

Contributors

Sandy Beck began her corporeal existence in Massachusetts. After graduating from a sheltered girls' prep school, she moved to New York City where she studied figure painting at the Art Students League and Film Studies at Hunter College. Subsequent years included travel in Southeast Asia, South America, and Europe, plus an MFA in Creative Writing. Currently, Sandy is working on a PhD in English. She lives by the sea in Port Townsend, Washington.

Félix T. Bermúdez de Castro y Sorondo's professional experience encompasses art, design, and architecture. He has won several art and design awards and has enjoyed a successful career with experience ranging from business, site management, and architectural projects such as retail, exhibition and leisure, conversions, the refurbishment of listed historic fabrics to a new luxury holiday villa. His talents and multiple skills have been profitably and successfully used across the board in England and other countries.

Robert Borski has written two books about the fiction of Gene Wolfe, *Solar Labyrinth* and *The Long and the Short of It*, and lives in central Wisconsin. He believes his exposure to the Duncan Yo-Yo Craze in the early 1960s, along with a fascination for Cat's Cradles and the like, predisposed him to an acceptance of string theory, but at the same time denies he still has trouble tying his shoes.

Carole Buggé has five published novels, four novellas and a dozen or so short stories and poems. Winner of the Euphoria Poetry Competition and the Eve of St. Agnes Poetry Award, she is also the First Prize winner of the Maxim Mazumdar Playwriting Competition, the Chronogram Literary Fiction Prize, Jerry Jazz Musician Short Fiction Award, and the Jean Paiva Memorial Fiction award, which included an NEA grant to read her fiction and poetry at Lincoln Center.

Daniel Conover is a journalist and new-media maverick in Charleston, South Carolina. He blogs, cartoons, and makes films with his friends at <http://xark.typepad.com>.

It's a long story why college librarian **Lloyd Daub** of Milwaukee writes poetry using both male and female pseudonyms. A long story. Fortunately, there is Deb Kolodji's version: "There's the interesting question of

oino sakai and **Lucinda Borkenhagen** being two different literary personalities of the same person…Have they met? In which dimension?"

Diane Shipley DeCillis' poems and prose have appeared in *Nimrod International Journal, Rattle, William & Mary Review, Gastronomica, Connecticut Review, South Dakota Review, Puerto del Sol, Poet Lore, Sanskrit, Slipstream, Phoebe* and other journals. She won the *Crucible* Poetry Prize 2005 and the 2005 *MacGuffin* National Poet Hunt. She owns an award-wining gallery in Southfield, Michigan and is co-editor of *Mona Poetica,* an anthology of poetry on the Mona Lisa published by *Mayapple Press.*

Lindsay A.S. Félix earned her BA in English from Mary Washington College in 1998 and MFA in Creative Writing from George Mason University in 2007. She teaches English composition at Northern Virginia Community College, works full time as a business analyst, and is a poet at night and on weekends. Lindsay married her fabulous husband, Marvin, in 2004 and has two wagging dogs, Max and Shamone.

Linda Nemec Foster is the author of seven books of poetry including *Amber Necklace from Gdansk* (finalist for the Ohio Book Award) and *Listen to the Landscape* (finalist for the Michigan Notable Book Award). Her poems have been published in over 250 literary journals (e.g. *The Georgia Review*, *New American Writing*, and *North American Review*), translated in Europe, and produced for the stage. She is the founder of the Contemporary Writers Series at Aquinas College in Grand Rapids, Michigan.

Cherryl E. Garner manages a small law office in South Carolina but has her deepest roots in Alabama, the inspiration for much of her poetry. Her poetic interest is in exploring family, landscape, the common and the divine in any forms that seem best to fit, and she waits patiently for an acceptable theory of everything. In the past year, her work has been included in *IBPC, The Rose & Thorn*, and *The Petigru Review*.

Paul Ginsparg is Professor of Physics and Computing & Information Science at Cornell University and is widely known for his development of the ArXiv.org e-print archive. He has published numerous papers in the areas of quantum field theory, string theory, conformal field theory, and quantum gravity. A Fellow of the American Physical Society, he has won many awards, including a MacArthur Fellowship in 2002, the PAM (physics astronomy math) Award from the Special Libraries Association, the Council of Science Editors Award for Meritorious Achievement, and the Paul Evans Peters Award.

Sheldon Glashow has done seminal research in the fields of elementary particle physics and cosmology. He played a key role in unifying the weak and electromagnetic forces and in creating today's successful Standard Model, for which he won, along with Steven Weinberg and Abdus Salam, the Nobel Prize for Physics in 1979. He is the Arthur G.B. Metcalf Professor of Physics at Brown University and author of some 300 research papers and three books: *Interactions* (with Ben Bova, 1988), *The Charm of Physics* (1990), and *From Alchemy to Quarks* (1993).

Andrea Gradidge, she who might be obeyed, in a dimension somewhere, has relocated in space from the UK to British Columbia, Canada. Her son, Benjamin, studies computer science, and her daughter, Jennie, emigrated back to England with husband Kevin and their boys. Andrea strings words into minimalist poems and also does some computer illustration.

Lauren Gunderson is a resident of New York City by way of Atlanta, earning her BA at Emory University. A nationally commissioned and produced playwright, as well as a short story author and poet, Lauren is currently pursuing her MFA in Dramatic Writing at Tisch School of the Arts at New York University. She teaches and speaks around the world on the intersection of science and theatre, as well as arts as activism. <http://laurengunderson.com>

Kathleen M. Heideman is a fellow of the National Science Foundation's Antarctic Artists & Writers Program. Her poems appear in the anthology *33 Minnesota Poets*, chapbooks (*Explaining Pictures to a Dead Hare*; *She Used to Have Some Cows; TimeUponOnce*), and various literary magazines — *Three Candles*, *Exquisite Corpse*, *Cream City Review*, *Water-Stone*, etc. Her poem "Woman in a Barrel, About to Go Over Niagara Falls" was nominated for a Pushcart. She lives in Minnesota.

Tania Hershman <http://taniahershman.com> is a former science journalist living in Jerusalem, Israel, and a founding member of the Fiction Workhouse online writing collective. Her short and very short stories have been published in *Cafe Irreal*, the *Hiss Quarterly*, *Front&Centre*, *Vestal Review*, *Steel City Review*, *Creating Reality*, *Entelechy Review*, the *Steel City Review*, *Riptide*, and *Transmission*, and the *Wonderwall* and *Ideas Above Our Station* anthologies from Route. She has had three stories broadcast on

BBC Radio 4. Tania's first collection, *The White Road and Other Stories*, will be published by Salt Publishing in 2008. Tania is the editor of *The Short Review* <http://theshortreview.com>, a site dedicated to reviewing short story collections and anthologies.

Brenda Hillman has published seven collections of poetry, all from Wesleyan University Press, the most recent of which are *Cascadia* (2001), and *Pieces of Air in the Epic* (2005), which won the William Carlos Williams Prize for Poetry. Hillman serves on the faculty of Saint Mary's College in Moraga, California, where she is the Olivia Filippi Professor of Poetry. She is involved in non-violent activism with Code Pink in the San Francisco Bay Area.

Heather Holliger is a teacher, poet, and activist in the San Francisco Bay area. She holds an MFA in creative writing from George Mason University and currently teaches writing and literature at Ohlone and Chabot Colleges. She is interested in the connections between poetry and social change and has served on the boards of several community-based poetry and spoken word organizations. She plans one day to found an artist community with fellow activists.

Daniel Hudon, originally from Canada, teaches natural science at Boston University. His first book, *The Bluffer's Guide to the Cosmos*, will be published in 2008 by Oval Books (UK). He has published more than two dozen travel stories in literary magazines, including, most recently, in *Bayou Magazine*. He is working on a series of short stories like the one in the present volume. He lives in Somerville, Massachusetts.

David Hurst's poetry has appeared in the online and print journals *Arsenic Lobster*, *In the Grove*, and *hardpan*. He feels the congruence of science and art is no accident; poetry walks that line merging code with rhythm, idiom and nuance. David received his MFA in Creative Writing at CSU, Fresno and teaches English at College of the Sequoias in Visalia, CA. He lives in California's Central Valley with his wife, several children, and various animals.

Colette Inez has authored nine books of poetry and won Guggenheim, Rockefeller and two NEA fellowships. Her latest collection *Spinoza Doesn't Come Here Anymore* has been released by Melville House Books, followed by her memoir *The Secret of M. Dulong* from the University of Wisconsin Press. A visiting professor formerly at Cornell, Ohio, Bucknell and Colgate

Universities, she is widely anthologized, teaches in Columbia University's Undergraduate Program, and has appeared on public radio and TV.

N.K. Jemisin is a writer of science fiction, dark fantasy, and unclassifiables like her contribution to this anthology. Her work has appeared in *Strange Horizons*, *Ideomancer*, *Escape Pod*, and on the 2006 Recommended Reading list from the Carl Brandon Society. She is fascinated by singularities, quantum or otherwise — including New York, where she now lives.

Jeff P. Jones's poetry chapbook, *Stratus Opacus*, is forthcoming from Main Street Rag Publishing. His poems are recently in *Blood Orange Review*, *Hawai'i Pacific Review*, *Puerto del Sol*, and elsewhere. He teaches writing at the University of Idaho.

Michio Kaku holds the Henry Semat Chair in Theoretical Physics at the City University of New York. He is the cofounder of string field theory and the author of several widely acclaimed books, including *Visions*, *Beyond Einstein*, *Hyperspace*, and most recently *Parallel Worlds*. He hosts a nationally syndicated radio science program. His website is <http://mkaku.org>.

Christine Klocek-Lim lives in Pennsylvania. Her poems have appeared in *Nimrod*, *The Pedestal Magazine*, *OCHO #5*, *About.com*, the *Quarterly Journal of Ideology*, and elsewhere. In 2006, her work was selected as a finalist for *Nimrod's* Pablo Neruda Prize for Poetry. She is editor of the online journal, *Autumn Sky Poetry*, and serves as Site Administrator for The Academy of American Poets' online discussion forum at *Poets.org*. Her website is <http://novembersky.com>.

Cleo Fellers Kocol proceeded from being a writer of fiction, non-fiction, and drama to poetry. *The Sacramento Bee* publishes her column about poets and poetry – also found online. Her poetry appears in *Poetry Now*, *Mobius*, and other journals, and was choreographed, set to music, and danced at the Palace of the Legion of Honor in San Francisco. She's also presented her poetry and drama at the Steve Allen Theater in Los Angeles, California. Kocol is 81 years old.

Deborah P. Kolodji works in information technology to fund other dimensions of her life, where she sometimes creates strings of haiku with other poets. Shunning the use of colorful pseudonyms, she is the president of the Science Fiction Poetry Association and a member of the Haiku

Society of America. Her work has appeared in a variety of places including *Modern Haiku*, *Strange Horizons*, *Frogpond*, *Eclectica*, *Poetic Diversity*, *Dreams and Nightmares*, and *St. Anthony Messenger Magazine*.

David Kopaska-Merkel describes rocks for the State of Alabama and publishes *Dreams and Nightmares,* a magazine of science fiction and fantasy poetry. In 2006, a collaboration with Kendall Evans won the Rhysling Award of the Science Fiction Poetry Association, long-poem category. Recent flash fiction can be found at <http://dailycabal.com>. Chapbooks are available through <http://genremall.com> and <http://spechouseofpoetry.com>. David lives in Alabama with artists and furry layabouts; learn more here <http://dreamsandnightmares.interstellardustmites.com>.

Dr. Kristine Larsen is Professor of Physics and Astronomy at Central Connecticut State University where she has been on the faculty since 1989. The author of *Stephen Hawking: A Biography*, *Cosmology 101*, and numerous articles on the history of women in astronomy and astronomy education, Larsen has also published and presented various scholarly works on the astronomical motifs and motivations in the works of J.R.R. Tolkien.

Elissa Malcohn edited *Star*Line* (Science Fiction Poetry Association) from 1986 to 1988. Her work has appeared in *Amazing*, *Asimov's*, *Full Spectrum* (Bantam), *Tales of the Unanticipated*, and elsewhere. She was a 1985 John W. Campbell Award finalist and a four-time Rhysling Award nominee. *Covenant*, the first volume in her *Deviations* series, is available from Aisling Press. Forthcoming fiction includes work in *Electric Velocipede* and *Helix*. See her website (search for "Malcohn's World") for more information.

Michelle Morgan's work appears in numerous journals, including *parva sed apta*, *Arsenic Lobster*, *JMWW*, *Salt River Review*, *The Aurorean*, *Plain Spoke*, *Pemmican*, *Ruined Music*, *Wicked Alice*, *Marginalia*, *Blood Lotus*, *Alimentum* & *New Verse News*, and in over half a dozen anthologies. She is editor of the online literary & arts journal *panamowa*: a new lit order, and she is also a graduate student in the R. Kelly School of Disembodied Metaphorics.

Dave Morrison, a high school graduate and above-average guitar player, has published two novels and two collections of poetry. Visit him at <http://dave--morrison.com>.

Conceived originally in Kiev, Ukraine, **Alex Nodopaka** was first exhibited by accident in Vladivostock, Russia. Then he finger-painted in Austria, studied tongue-in-cheek at the École des Beaux-Arts, Casablanca, Morocco. Now he's back to doodling with crayons but on human canvases. Full time artist, art critic, and poet, he still dreams of silent acting in an IFC or Sundance movie.

James O'Hern is the author of *Honoring the Stones* published by Curbstone Press. Raised on a ranch in South Texas, he was mentored by a Mexican Indian who taught him native ways. Thus, he became profoundly aware of how progress erases the collective memory of indigenous people. After 35 years as an investment banker, he is committed to honor the loss of cultural identity through language and poetry. He lives in New York City. <ohern_j@msn.com>

Lynn Pattison's work has appeared in: *The Notre Dame Review*, *Rhino*, *The Dunes Review*, *Heliotrope*, *The MacGuffin* and *Poetry East*. Besides her chapbooks, *tesla's daughter* and *Walking Back the Cat*, she is the author of the book, *Light That Sounds Like Breaking*. Her poems have been anthologized in several collections and have twice been nominated for the Pushcart Prize. She imagines that in another dimension she might really understand quantum physics.

Joseph Radke's poems have appeared in *Boulevard*, *Versal*, *Poetry East*, *Natural Bridge*, and several other journals. He is the recipient of an Academy of American Poets prize. He lives in Milwaukee where he teaches writing and works on *The Cream City Review*. *Salt&Sand*, his poetry manuscript, is seeking a publisher.

Michael Ricciardi is naturalist, teacher, writer/poet, designer, and multimedia artist living in Seattle, Washington. He is also a former professional illusionist. As a science writer/reporter, Michael has interviewed several renowned scientists, including physicists Brian Greene (Columbia), Paul Steinhardt (Princeton), and Nobel Laureate Ilya Prigogine. Ricciardi is also an award winning, internationally screened video artist, and has received several grants for his artistic projects, including a Paul G. Allen Foundation for the Arts grant (2002, 2003).

Adam Roberts was born two thirds of the way through the last century. He is currently Professor of Nineteenth-century Literature at Royal Holloway, University of London. Perhaps surprisingly, given that fact, he is also the author of a number of science fiction novels, the most recent of which are: *Gradisil* (Gollancz, 2006, which was shortlisted for the Arthur C. Clarke award), *Splinter* (Solaris 2007), *Land of the Headless* (Gollancz 2007) and *Swiftly* (Gollancz 2008).

Bruce Holland Rogers is an American writer living temporarily in London. His fiction has been translated into 23 languages and has won a Pushcart Prize, two Nebulas, and two World Fantasy Awards. His most recent collection is *The Keyhole Opera*, and more of his stories are available at <http://shortshortshort.com> along with information about an e-mail subscription service to his short-short stories. He teaches fiction writing for the Whidbey Writers Workshop low-residency MFA program.

Mary Margaret Serpento (a.k.a. *.mms) writes SF short poetry in English and French, and is a figment of her own imagination.

scifaijin Celtic and bilingual—
  a cat reborn as human
  this turn (of the wheel)

Beret Skorpen-Tifft writes poetry and fiction. She lives in South Portland Maine with her husband and two children. She received her B.A from Hampshire College and her MFA in fiction from Vermont College. Her work has appeared in *The Louisville Review, Passages North, The Red Owl, The Sow's Ear, The Sun, Maine Things Considered, The Maine Times, and The Bangor Daily News.* She is a long distance runner, completing 7 marathons.

Jarvis Slacks attends the University of North Carolina at Wilmington, finishing his masters degree in Creative Writing. He also writes a weekly nightlife column, *Good Evening*, for the *Star News* and is working on his first novel. He likes cookies and ice cream.

Elaine Terranova's most recent book of poems is *Not To: New and Selected Poems*. Other books include *The Cult of the Right Hand*, for which she won the 1990 Walt Whitman Award of the Academy of American Poets, *Damages*, and *The Dog's Heart*. Her translation of Euripides' *Iphigenia at Aulis* is part of the Penn Greek Drama Series. She was named a Pew Fellow in the Arts and has received an NEA fellowship.

Wendy Vardaman, Madison, Wisconsin, has a PhD in English from University of Pennsylvania, as well as a BS in Civil Engineering from

Cornell University. Her poems, reviews, and interviews have appeared in various anthologies and journals, including *Poet Lore*, *Main Street Rag*, *Nerve Cowboy*, *qarrtsiluni*, *Free Verse*, Pivot, *Wisconsin People & Ideas*, *Women's Review of Books* and *Portland Review*.

Cecilia Vicuña is a poet and artist born in Chile. She performs and exhibits her work widely in Europe, Latin America, and the US. The author of 16 books, her work has been translated into several languages. Among them: *QUIPOem*, Wesleyan University Press, l997, and *Spit Temple,* forthcoming by Factory School Press, 2008. The co-author of *500 Years of Latin American Poetry* for Oxford University Press, she lives in New York and Chile. <http://ceciliavicuna.org>

Peter Woit is a Lecturer in the mathematics department at Columbia University and a researcher in the field of mathematical physics. He holds a doctoral degree in theoretical particle physics from Princeton and writes a blog, *Not Even Wrong*, which often takes a critical view of string theory. His book of the same name was published in 2006 in the US and the UK and has recently appeared in Italian and French translations.

Susan Zwinger has published seventy poems and five books of natural history, including *The Last Wild Edge*, *Stalking the Ice Dragon*, *Still Wild, Always Wild*, a Sierra Club book. She teaches for the Whidbey Writers Workshop Master of Fine Arts in creative nonfiction, keeps illustrated journals, and leads natural history and creative writing workshops across the West. Zwinger has an MFA in Poetry from University of Iowa in 1971. She lives on an island where she translates from eagle to English daily.

About the Editors

Sean Miller is finishing up a PhD in English at the University of London. His topic is "the cultural currency of string theory." Sean has published two novels and poetry in journals. Raised in Connecticut, he's travelled extensively, living and working in China, Japan, Spain, and India.

Shveta Verma has two masters, one in literature, the other in education. She has taught English in New York City high schools and is interested in postcolonialism and cultural anthropology. Her family emigrated to the U.S. from the Punjab when she was two.

Sean and Shveta met during a Masters course at Birkbeck College in London in 2003. In 2007 they got married in Maui and honeymooned in Peru.

About Scriblerus Press

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