DRIFTING OUT TO INFINITY

DANIELLE SPENCER

PLOUGHSHARES SOLOS

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> *Jack sat pondering his father, and there was something in his face more absolute than gentleness or compassion, something purged of all the words that might describe it.*
> — *Home*, Marilynne Robinson

2. Genesis:
In the beginning was the Word,
and the Word was with God,
and the Word was God.

3. My father is a mathematician.
The equivalence of the two terms: father⇔mathematician.
The Number is *with* the Father, and the Number *is* the Father.
The cadence, the consonance of the *th* sounds in father and mathematician, both furry and portentous: *Theory, earth, oath, dearth, thought, thunder.*

5. There is a distinctive cool cinderblock smell to math departments everywhere. Conference posters fluttering on the office doors, the glossy canary-yellow spines of Springer textbooks. A red-bearded man in black socks and sandals walks amiably down the hall carrying a cup of coffee and a pad of paper, a one-armed wristwatch pinned to his breast pocket. I am six years old, and the daylight from the window at the end of the hall next to my father's office casts a cloudy oblong reflection down its length. Inside, my clay stegosaurus stands diffidently atop his gray metal filing cabinet. Looking up at the smudged blackboard, the most insistent chirping chalk equations are boxed, marked DO NOT ERASE.

My father's office is still at the end of the hall, though now at a different university, a brick tower in a city. This institute of mathematical

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sciences used to be true to form in its peeling vinyl flooring, but the floors have since been covered in a high-shellac wood veneer. When you step into the offices, it is the same as it has always been—bad math art for the professors, four to a narrow room for the graduate students from India, Russia, China—and will continue to be.

Describing these details is like sitting in the stands of a baseball game and focusing on the uniforms, asking why some players wear knee socks while others do not; such appearances (and analogies) are not intrinsic to the game. The material world is immaterial.

7. Socrates:

> And do you not know also that although [students of mathematics] make use of the visible forms and reason about them, they are thinking not of these, but of the ideals which they resemble; not of the figures which they draw, but of the absolute square and the absolute diameter, and so on—the forms which they draw or make, and which have shadows and reflections in water of their own, are converted by them into images, but they are really seeking to behold the things themselves, which can be seen only with the eye of the mind?
>
> […] And when I speak of the other division of the intelligible, you will understand me to speak of that other sort of knowledge which reason herself attains by the power of dialectic, using the hypotheses not as first principles, but only as hypotheses—that is to say, as steps and points of departure into a world which is above hypotheses, in order that she may soar beyond them to the first principle of the whole; and clinging to this and then to that which depends on this, by successive steps she descends again without the aid of any sensible object, from ideas, through ideas, and in ideas she ends.
>
> — Plato, Republic VI

Soaring into a world above hypotheses—in ideas she ends. Or, in the Bhagavad Gita, reaching *that in which he finds this supreme delight, perceived by the intelligence and beyond the reach of the senses, wherein established, he no longer falls away from the truth.* [6.21]

11. Yet the opposite drive accompanies abstraction: the impulse to render the intelligible realm material. Norton Juster's 1961 children's book *The Phantom Tollbooth* tells the story of a gloomily bored boy named Milo who apparently found nothing of interest in the world. *"It seems to me that almost everything is a waste of time," he remarked one day as he walked dejectedly home from school.* He arrives home to find an enormous package in his bedroom, accompanied by a note:

ONE GENUINE TURNPIKE TOLLBOOTH
EASILY ASSEMBLED AT HOME, AND FOR USE BY THOSE
WHO HAVE NEVER TRAVELED IN LANDS BEYOND.

For lack of anything better to do Milo assembles the kit *("I do hope this is an interesting game, otherwise the afternoon will be so terribly dull"),* takes the enclosed map and rule book, and navigates his toy car through the purple tollbooth. He soon finds himself driving along an unfamiliar road in a new land:

> What had started as make-believe was now very real. "What a strange thing to have happen," he thought (just as you must be thinking right now). "This game is much more serious than I thought, for here I am riding on a road I've never seen, going to a place I've never heard of, and all because of a tollbooth which came from nowhere."

Milo first stops in the land of Expectations—*the place you must always go to before you get to where you're going*—and meets the Whether Man before languishing in the Doldrums, where he is surrounded by Lethargarians. While in the Doldrums he meets a large watchdog named Tock, with the head, feet, and tail of a dog and the torso of an enormous ticking alarm clock, shaggily drawn by illustrator Jules Feiffer. Tock joins Milo in the car and they continue on their journey, traveling first to Dictionopolis, ruled by King Azaz the Unabridged, and then Digitopolis, led by the Mathemagician—two brothers warring over which is superior, words or numbers. In Dictionopolis Milo and Tock visit the Word Market, ducking from the Spelling Bee. In Digitopolis they meet the Mathemagician, and Milo asks to see *the biggest number there is*:

> "I'd be delighted," [the Mathemagician] replied, opening one of the closet doors. "We keep it right here. It took four miners just to dig it out."

> Inside was the biggest 3 Milo had ever seen. It was fully twice as high as the Mathemagician.
>
> "No, that's not what I mean," objected Milo. "Can you show me the longest number there is?" "Surely," said the Mathemagician, opening another door. "Here it is. It took three carts to carry it here."
>
> Inside this closet was the longest 8 imaginable. It was just about as wide as the three was high.

This is child's play, but it is serious play too, for our love of earthly forms draws us to higher truths, yet the tollbooth takes us to a land where abstractions—including numbers and metaphors—become personified. We move from literal to figurative and back again, a dizzying ride through the ancient Indian board game of Moksha Patam (later adapted by the British as Snakes and Ladders and then marketed in the US by Milton Bradley as Chutes and Ladders) where a roll of the dice can bring you quick advancement or a steep descent. It was originally designed as an allegorical morality tale about virtue, vice, destiny, and salvation.

LEGO®—from *leg godt*, Danish for *play well*—has patented the SERIOUS PLAY® Method as a corporate team-building and problem-solving technique in which a trained facilitator prompts participants to render the figurative material: The use of LEGO® bricks *simply enables you to take a speedy shortcut to the core. The bricks work as a catalyst—and when used for building metaphors, they trigger processes that you were previously unaware of.*

Milo's journey through a gateway into another world is a familiar one. It is the portal-quest fantasy: Alice, intrigued by the rabbit pulling a watch out of his waistcoat pocket as he hurries past, following him only to tumble down the rabbit hole; Dorothy's passage from Kansas to the Emerald City (one of Juster's favorite childhood books); Lucy, Peter, Susan, and Edmund's expedition to Narnia *("This must be a simply* *enormous wardrobe!" thought Lucy, going still further in and pushing the soft folds of the coats aside to make room for her*), Frodo Baggins' journey to Middle-earth. In these tales we trust that the protagonist will return safely home, tired yet enlightened.

In some cases portals lead to new domains from which we will not return. As Farah Mendlesohn points out in *Rhetorics of Fantasy*, the Christian heaven is the definitive gateway: *What else is a posthumous heaven (a notion almost completely absent from the Old Testament) other than the ultimate in portals?*—a mortal threshold to another realm. Though it needn't be our final resting place. Plato thought the soul to be immortal, reincarnated in any given material being, like waking after sleep. In the *Meno* dialogue Socrates questions an unschooled slave boy about elementary geometry, arguing that the boy's knowledge of mathematical truths was *awakened into knowledge* through his questioning and so must have been learned in a previous life, thus demonstrating the immortality of the soul. In Hinduism, too, the soul is immortal. You may reach a heavenlike plane, but it is not the final stop. In a sense, all of life is a portal, and you will keep cycling through different planes, perhaps multiple universes—perhaps an infinite number of universes—before attaining *moksha*, the liberation at the top of the Snakes and Ladders game.

13. When my mother's cousin Win was dying young of heart disease, he was removed from life support but he did not die immediately. His brother, eager for his suffering to end, pounded on his chest (not the best way to hasten his death, come to think of it) and shouted, *Cross over, Win! Cross over!*

Passages, voyages. What do we find along the way? *Something happened, something so memorable that when I think back to the crossing of the bridge, one moment bulges like the belly of a lens and all of the others are at the peripheries and diminished.* —Marilynne Robinson, *Housekeeping.*

17. Another tale of a land split by two warring brothers was told several thousand years before the story of King Azaz the Unabridged and the Mathemagician and continues to be told today. The great ancient

Indian epic Mahabharata (महाभारतम्) describes a kingdom divided by blind King Dhritarashtra and his brother King Pandu, progenitors of the Kauravas and the Pandavas. The Kauravas claim the entire land after trickily winning a game of *chausar*, played with square cuboid dice, each rectangular facet bearing • or •• marked at three points along its length. Following a period of exile the Pandavas return to try to recoup the kingdom in battle at Kurukshatra.

It is at this point that the Bhagavad Gita—"Song of the Lord"—scripture begins: On the brink of warfare, Arjuna, a descendent of King Pandu, stops short, hesitant to slay his own relatives, and conducts a lengthy philosophical discourse with Lord Krishna. It is a quest narrative, as Arjuna is on a journey (indeed, Krishna is serving as his charioteer—every traveler needs a companion/guide, be they an incarnation of the divine or a canine alarm clock) and he must decide whether or not to go forward and fight on the battlefield, itself a figure for the field of life. The story is told to King Dhritarashtra by his minister Sanjaya who uses his divine senses—a kind of portal vision—to report on the battle far from Kurukshatra. As Sanjaya recounts, Krishna explains to Arjuna that he should do his duty, follow his *dharma*, and fight. One must act, yet must remain unattached to the results of one's actions. Moreover, Arjuna must not fear slaying his relatives, for the soul is unchanging: *Never was there a time when I was not, nor thou, nor these lords of men, nor will there ever be a time hereafter when we all shall cease to be.* [2.12] Death is merely a gateway to another life: *He is never born, nor does he die at any time, nor having (once) come to be will he again cease to be. He is unborn, eternal, permanent and primeval. He is not slain when the body is slain.* [2.19] After much discussion, Arjuna (spoiler alert) enters the battle.

What is the moral of the story? Truth be told, there is no single moral, as the tale deflects any reductive interpretation. *To put it bluntly, the utility of the Gita derives from its peculiar fundamental defect, namely, dexterity in seeming to reconcile the irreconcilable. The high god repeatedly emphasizes the great virtue of non-killing* (ahimsa), *yet the entire discourse is an incentive to war.* [D. D. Kosambi] Many have cited the text as an argument for violence, yet one can find in it a justification for *non*-violence, as Gandhi did, interpreting the battle as a struggle we must wage against aspects of our own selves and our attachments in order to attain brahman, or Infinite Spirit, which lies within us all.

A path to truth—to infinity—is dialectical, it appears. We struggle with the tension between finitude (perhaps understood as wordly action) and infinity. One of the ways we approach this balance is through narrative.

> What I believe to be the best set of records we have about ourselves [are] stories of all kinds, true, embellished, invented. We are often taught to deal with ideas as the highest form of knowledge. But the process of abstraction by which we form ideas out of observed experience eliminates two essential aspects of life that I am unwilling to relinquish: time and individual people acting as agents. At their purest, ideas are disembodied and timeless. We need ideas to reason logically and to explore the fog of uncertainty that surrounds the immediate encounter with daily living. Equally, we need stories to embody the medium of time in which human character takes shape and reveals itself to us, and in which we discover our own mortality.
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> — Roger Shattuck, *Forbidden Knowledge*

19. Returning to our story from the detour up the ladder and down the slide, now back to the Mathemagician's biggest 3 and longest 8: It is true that the integers have different shapes and personalities. Some are boorish and self-absorbed, while others are electrifyingly enigmatic, potent. Some stand on one leg with smug nonchalance, like 9, which feels as though it *should* be a prime, but of course it's a *square*, silly!—while others are bloviating blowhards, not to name names (10). And then a few special, *perfect* numbers like 6 and 28 whose factors, excluding the number, add up to themselves. These characters can be sequenced to explosive (Fibonacci) or dull (even numbers) effect, like a clutch of lovers—spurned, former, desired—seated together at a dinner party.

At every family birthday my father remarked on the new age's qualities. Primes, of course, were always superior years. They are the bedrock of all, the "atoms of the integers"—the individual LEGO® bricks from which all else is made—as they have no factors save the number itself and 1, and all other composite numbers are formed of prime factors.

They are fickle, too, behaving as though they are distributed randomly, but obeying certain laws. Plus, there are so gratifyingly many in one's earliest years—their frequency diminishes as you advance, albeit quite slowly. I just turned a twin prime, one of a set of two primes separated only by two, such as 17 and 19, where we are resting now. I hope to reach two or three more sets in my lifetime depending upon how far I travel. We know that there are an infinite number of primes, but we do not yet know if there are an infinite number of *twin* primes; the twin prime conjecture, postulating that there *are* an infinite number of primes with a prime gap of two, is one of the great longstanding unsolved problems in number theory.

These days, though, I am less likely to know what is numerically intriguing or lackluster (as the case may be) about my age. The numbers' edges have blurred, dulled by the whetstone of time and by the ponderous metaphors used to describe its effects. Picture a pair of polyhedral dice that have become scratched and worn with use to the point that they will not rest on a given facet but instead wobble and roll maddeningly.

23. In 1914 the brilliant and largely self-taught Indian mathematician S. Ramanujan boarded the SS *Nevasa* of the British India Lines fleet and traveled from Madras to London and then continued on to Trinity College, Cambridge to work with mathematician G. H. Hardy. He was twenty-six years old. During his time in England he was prodigiously productive but also fell quite ill. Hardy recalls one of his visits to see Ramanujan in a London sanatorium: *I had ridden in taxi cab number 1729 and remarked that the number seemed to me rather a dull one, and that I hoped it was not an unfavorable omen. "No," he replied, "it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways."*

$$1^3 + 12^3 = 1729$$
$$9^3 + 10^3 = 1729$$

Ramanujan was a Brahmin, raised in Kumbakonam, a village in Tamil Nadu, in the southern region of India. His father was an accountant, like my father's father. In Robert Kanigel's 1991 biography *The Man Who Knew Infinity* (source of the 2015 film of the same name) much is made of the spirituality of Ramanujan's home region: *In 1904, some boys thought they heard trumpets coming from an anthill, and soon the deity of the anthill was attracting thousands of people from nearby villages, who would lie "prostrate on their faces, rapt in adoration."* Ramanujan often credited the goddess Namagiri with his mathematical insights. As Kanigel explains, *all his life [Ramanujan] believed in the Hindu gods and made the landscape of the Infinite, in realms both mathematical and spiritual, his home. "An equation for me has no meaning," he once said, "unless it expresses a thought of God."* His Indian biographers Seshu Aiyar and Ramachandra Rao described Ramanujan's faith in a Supreme Being in detail. But Hardy maintained that Ramanujan told him *that all religions seemed to him more or less equally true*.

Ramanujan's first letter to Hardy in 1913 begins:

> Dear Sir,
>
> I beg to introduce myself to you as a clerk in the Accounts Department of the Port Trust Office at Madras on a salary of only £20 per annum. I am now about 23 years of age. [He was in fact 25.] I have had no University education but I have undergone the ordinary school course. After leaving school I have been employing the spare time at my disposal to work at Mathematics. I have not trodden through the conventional regular course which is followed in a University course, but I am striking out a new path for myself. I have made a special investigation of divergent series in general and the results I get are termed by the local mathematicians as "startling."

The letter quickly turns to mathematics, including a response to Hardy's paper on orders of infinity in which Ramanujan proposed an astonishing result concerning the prime number theorem, offering two infinite series which closely approximated the number of primes at a given number. (Among Ramanujan's many interests were infinite sequences and series, which are a series of terms that are added or multiplied together, producing a particular sum or product—so for example, ½ + ¼ + ⅛… on to infinity equals 1.) Hardy, after consulting with his colleague Littlewood, replied to Ramanujan, pointing to *gaps in the proof* rendering it incorrect: *The truth is that the theory of primes is full of pitfalls, to surmount which requires the fullest of trainings in* *modern rigorous methods*, Hardy explained. *This you are naturally without. I hope you will not be discouraged by my criticisms. I think your argument a very remarkable and ingenious one. To have proved what you claimed to have proved would have been about the most remarkable mathematical feat in the whole history of mathematics.*

Indeed, Ramanujan *was* one of the most remarkable figures in the whole history of mathematics, though he and Hardy continued to differ over the question of proof—that is to say, what constitutes a proper proof. During his time in Cambridge he and Hardy published key papers on such topics as the likely number of prime divisors for a particular integer, and the famous partition problem, concerning how many different ways one can express a given number as a sum of lesser numbers. In 1850, Chebyshev had proved that between an integer and its double there is always a prime (e.g. 3 lies between 2 and 4); in 1919, Ramanujan proved it again without using complex numbers—an "elementary" proof that once n is large enough, you will always find 10 primes between n and 2n—and then in 1931, at the age of 18, the great Hungarian mathematician Paul Erdős proved it again with a proof that was both elementary and simple. The simple, elegant proof is the holy grail. Erdős had not known of Ramanujan's proof, so he asked Hardy about him when they met in Cambridge.

By that time Ramanujan had returned to India, where he died soon after at the age of 32. He had proved *thousands* of theorems, and many first-rate mathematicians have spent years poring over his notebooks attempting to interpret them, as they are not written in standard proof form. Many of these decipherers speak of the experience as something akin to divine revelation—like Mormon forefather Joseph Smith Jr., reading the sacred golden plates dug up from his backyard in upstate New York through a jewel in his hat. Or rather like a mathematical garden of delight, which has germinated and populated many fields, as theoretical physicist and mathematician Freeman Dyson describes:

> The seeds from Ramanujan's garden have been blowing on the wind and have been sprouting all over the landscape. Some of the seeds even blew over into physics… [and superstring theory]. Whether or not the superstring theory is a true image of nature, it is certainly a magnificent creation of pure mathematics. As pure mathematics, it

> is as beautiful as any of the other flowers that grew from seeds that ripened in Ramanujan's garden.

Superstring theory could resolve an apparent mathematical contradiction between the theory of relativity and quantum mechanics. If the theory is a true image of nature, it suggests that we may be living in a megaverse / multiverse / metaverse composed of an infinite number of parallel universes—though we would probably have no way of knowing for sure.

29. When I was twelve my father worked through Euclid's famous proof of the infinitude of primes with me. It is a proof by contradiction, first assuming that the primes are finite and then creating a number, P+1—the product of all existing primes plus one—and demonstrating that it is neither prime nor composite: If P+1 *is* prime, then P is *not* the last prime. If P+1 is *not* prime, then it *must* have a prime factor—all composite numbers do—yet when P+1 is divided by any of the "existing" primes, you are left with a remainder of 1, since they are all factors of P. Thus P+1 cannot exist, and the primes continue to infinity.

How did Euclid know to bring into existence this number which erases itself, and in its very nonexistence (yet does it not exist in our imagination?) proves—with a devastating simplicity that a twelve-year-old can grasp—that the primes are infinite? As Hardy describes, reductio ad absurdum, *which Euclid loved so much, is one of a mathematician's finest weapons. It is a far finer gambit than any chess gambit: a chess player may offer the sacrifice of a pawn or even a piece, but a mathematician offers* ***the game.***

My father went on to explain that proof by contradiction is a common technique in tackling any given conjecture. A conjecture is essentially a hypothesis that has some supposition or intuition of being true (better yet if it incorporates partial results and/or provokes the development of new methods for its proof). So for reductio ad absurdum you first assume that the entire conjecture is false—as Hardy put it, betting the game—and then see if you can prove a contradiction. If you cannot, the conjecture may still be true; most likely you failed because you are not clever enough, or perhaps the requisite tools have not yet been invented/discovered (⇐ this distinction depends upon your philosophical view of mathematics—constructivism vs. Platonism).

I remember asking if it ever happens that you wind up proving the opposite, which is to say that the conjecture *is* false, and my father told me about the long line of seekers attempting to prove Euclid's "parallel postulate" concerning lines stretching to infinity. Playfair later expressed the postulate as the axiom that, given a line A on a plane and a point not on the line, there will only be one line that goes through the point and lies parallel to A, never touching it. Seems obviously correct, no? Yet intuition is not proof. In trying to reach a proof by contradiction mathematicians encountered a Pyrrhic defeat—to use my father's term—as early nineteenth-century figures such as Gauss, Lobachevsky, Bolyai, Reimann, Minkowski and others arrived at non-Euclidean geometry, or hyperbolic geometry, in which space and time are joined. Thus we leave Euclidean planar geometric space, jumping through the portal from one familiar universe to entirely different ones, following Alice through the looking glass once again.

Alice's creator Lewis Carroll was a nom de plume for mathematician Charles Dodgson of Christ Church, Oxford. Wonderland is rife with mathematical allusions, taking then-novel concepts such as imaginary numbers to their logical yet absurd conclusion—itself a literary form of reductio ad absurdum, as scholar Melanie Bayley points out. In Bayley's analysis, projective geometry is represented by the duchess' baby's transformation into a pig, while noncommutative algebra is spoofed by the Mad Hatter's Tea Party. Symbolic logic is enacted by the Caterpillar's mushrooms, which simultaneously shrink and expand Alice, and his injunction to *Keep your temper* refers to proportions, i.e., stick to Euclidean geometry, where ratios remain the same, whatever the size.

Indeed, Dodgson was quite an apologist for Euclidean geometry in the face of new-fangled developments in mathematics, arguing for continued use of Euclid's Manual in education. (K. G. Valente: *Questioning the primacy of Euclidean geometry directly threatened the notion of absolute truth and precipitated a paradigmatic dilemma as unsettling as any attending the dissemination of evolutionary theories.*)

Combining his modest mathematical faculties with his literary talents, Dodgson's 1879 *Euclid and his Modern Rivals* is written as a play, with the cast of characters debating the new theories of geometry in Socratic dialogue. In Scene I the character of Minos satirizes current mathematical methods and their specious—in his view—conception of proof:

> Did you ever see one of those conjurers bring a globe of live fish out of a pocket-handkerchief? That's the kind of thing we have in Modern Geometry. A man stands before you with nothing but an Axiom in his hands. He rolls up his sleeves. 'Observe, gentlemen, I have nothing concealed. There is no deception!' And the next moment, you have a complete Theorem, Q.E.D. and all!

And in Scene II Euclid himself appears to endorse his treatise. Minos asks if Euclid can invoke the various Modern Rivals for the sake of debate, and Euclid produces a phantasm of a German professor to stand in for them; when Minos enquires after his name, Euclid explains that *Phantasms have no names—only numbers. You may call him 'Herr Niemand,' or, if you prefer it, 'Number one-hundred-and-twenty-three-million-four-hundred-and-fifty-six-thousand-seven-hundred-and-eighty-nine.'*

Erdős' father showed him Euclid's proof of the infinitude of primes just as my father showed me. *When I was ten my father told me about Euclid's proof, and I was hooked*, he explained. I can still see the proof as written on the page and the sense of wondrous unfolding into another realm. Yet it's a bit like having heard tales of the starry night sky but only glimpsing a bit of twilight now and then. I was always more interested in words than in numbers, and stopped my math studies after calculus. Far enough to dimly discern—as my father pointed toward certain constellations—that there is a beauty that must be experienced to be understood, and must be understood to be truly experienced.

31. In the 1993 documentary *N Is a Number* about Paul Erdős my father is interviewed several times. He was one of Erdős' inner circle of disciples, as they called themselves, and the two collaborated on many papers and a book. In the interviews my father is *shockingly* young. A black mop of hair, a very 1980s-style sweater from Marshalls department store, and the vertical furrow at the medial edge of his left eyebrow appearing during moments of intense concentration, which I have inherited. In one scene he is describing the certainty of mathematical truth and invokes Euclid's proof:

> Where else do you have absolute truth? You have it in mathematics, and you have it in religion. In mathematics you can really argue that this is as *close* to absolute truth as you can get—and so when you ask a problem—are there an infinite number of primes?—classic Greek problem—when that was solved in ancient Greece, when Euclid showed that there were an infinite number of primes—that's *IT*—there *ARE* an infinite number of primes, and there are no ifs, ands, or buts. That's as close to absolute truth as *I* can see getting.

His voice is earnest and impassioned, hitting the *that's IT* with a nasal finality stretching to the edge of the horizon and beyond. What he actually said was, *Where else do you have absolute truth? You have it in mathematics, and you have it in religion—at least for* some *people—* this last bit accompanied by a rueful chuckle. The director edited out the qualification, mollifying my father's message: Theology offers a descriptive language, but in the end the Temple of Mathematics is the only means of access to the Divine.

Mathematics as the purest form of knowledge. The rhetoric of purity can be quite dangerous, however, as it draws a circle around a set, and all that lies outside is impure.

37. In this view even the physical sciences are contaminated, sullied by the messy evidentiary morass of the material world. If you meet a theoretical mathematician or physicist who does "pure" or "basic" research and ask about the practical applications of their work, they will likely look down at you with pity and annoyance, for you are trapped in Plato's cave, blinking at the shadows on the wall. As Hardy explains in *A Mathematician's Apology*, physical reality and mathematical reality are distinct.

In fact, the pursuit of interesting and aesthetically appealing math problems often leads to knowledge that *is* extremely applicable. Euclid did not see any utility in studying prime numbers, but prime factorization is the basis for public-key cryptography, now essential to secure electronic communication. Emmy Noether's mathematical theorems became integral to the general theory of relativity, as did "pure" Tensor calculus, which was developed with no earthly application in mind—yet in addition to helping us understand the structure of the universe, relativity is necessary for technologies such as GPS. Nuclear fission and the atomic bomb, of course, are prime examples of impactful technology reliant upon mathematical understanding. During WWII Los Alamos National Laboratory drew many of the keenest minds in pure math and physics research of that era. Erdős was interested in contributing but was not offered a position, perhaps because he maintained that he intended to return to Hungary after the war and was famously indiscreet. Biographer Paul Hoffman tells of Erdős' postcard to Hungarian-born mathematician Peter Lax (now in his 90s—his office is down the hall from my father's) during the war: *Dear Peter, my spies tell me that Sam* [Erdős' nickname for the US] *is building an atomic bomb. Tell me, is that true?* (The FBI evidently tracked Erdős for decades, only to conclude that he was *purely a mathematician with typical atmospheric mind as related to factual things.*)

As Laboratory Director Robert Oppenheimer watched the great flash of the first Trinity test in the Los Alamos desert, he thought of the passage in the Gita [11.12] when Arjuna asks Lord Krishna to reveal himself. Krishna replies:

> *If the radiance of a thousand suns*
> *were to burst into the sky,*
> *that would be like*
> *the splendor of the Mighty One.*

Then, thinking of his own responsibility for the bomb's creation, Oppenheimer famously recited verse 11.32 to himself: *Now I am become death, the destroyer of worlds.*

The struggle over the morality of American bombing of Hiroshima and Nagasaki reflects the ethical plurality of the Gita: When and how should one wage war? Oppenheimer's seemingly contradictory stance—architect of the Manhattan Project and later opponent of the production of the hydrogen bomb—symbolizes the eternal Ouroborus of scientific progress, morality, and responsibility, an ethical quagmire which is irreducible, finally, to linear proof. Shortly after the war Oppenheimer delivered a lecture at MIT about the role of the scientist; according to Roger Shattuck, Oppenheimer referenced the principle of complementarity—in quantum mechanics, the notion that a physical object can possess complementary characteristics, such as the wave and particle attributes of light—to describe science itself:

> In other words, he described two conflicting interpretations and affirmed the truth of both. They complement each other as partial, not exhaustive, truths. On the one hand, the value of science lies in its fruits, in its effects, more good than bad, on our lives. On the other hand, the value of science lies in its robust way of life dedicated to truth, disinterested discovery, and experiment.

Yet, in what may seem like further contradiction, Oppenheimer's speech went on to describe scientists' responsibility for atomic weapons. As he explained: *In some sort of crude sense which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin; and this is a knowledge which they cannot lose*. The physicists have known sin. Mathematicians may feel immune from the physicists' iniquity, but as Shattuck explains, *The frontier between pure and applied is a phantom that appears on many maps yet cannot be located easily on the terrain*.

Regardless, arguments about the real-world results of "pure" math do not justify or damn its value from the perspective of mathematicians like Hardy, who maintains that *Beauty is the first test: there is no permanent place in the world for ugly mathematics*. When Paul Erdős and one of his many collaborators arrived at a proof that was correct but inelegant, he would say, *Good, but now let us look for the Book proof*. The Book contains all of the most beautiful theorems—beginning with Euclid's proof of the infinitude of primes—and it is the work of mortals to try to turn a few more pages.

My father always ascribed the notion of the Book to Uncle Paul, as we called him, quoting his maxim: *You don't have to believe in God,* *but you should believe in the Book*. But in fact it has been around for quite a long while. The ancient Greeks held that human reason can unlock the mysteries of the world, and medieval Christian theologians, drawing upon this model, proposed that God's revelation is present in the scriptures, as well as the Book of Nature; thus their study provides a means of accessing the divine. And then there is Galileo Galilei's famous description:

> Philosophy [nature] is written in that great book which ever is before our eyes—I mean the universe—but we cannot understand it if we do not first learn the language and grasp the symbols in which it is written. The book is written in mathematical language, and the symbols are triangles, circles and other geometrical figures, without whose help it is impossible to comprehend a single word of it; without which one wanders in vain through a dark labyrinth.

Not to mention Borges' Library of Babel:

> It does not seem unlikely to me that there is a total book on some shelf of the universe… I pray to the unknown gods that a man—just one, even though it were thousands of years ago!—may have examined and read it. If honor and wisdom and happiness are not for me, let them be for others. Let heaven exist, though my place be in hell. Let me be outraged and annihilated, but for one instant, in one being, let Your enormous Library be justified.

My father's preference to speak only of Erdős as the progenitor of the idea of the Book is a form of fantasy that he authored the story of the Book. In the beginning was the Word, and the Word was with God the Father, and the Word *was* God. Erdős was my father's *real*—which is to say mathematical—father.

41. The argument I began having with my father in adolescence went something like this:

> Him: Math is *pure.*
> Me: You have a National Science Foundation grant. Why do you think the

federal government funds your field and not others to the same extent?
Him: *Math* is pure.
Me: You went to MIT for undergrad. 70 percent of its budget came from the Department of Defense.
Him: [Angrily] *Math is pure.*

I was doing what I was supposed to be doing, poking at the idols and sullying the temple, arguing for the social construction and situation of knowledge. For one thing, support of "pure" research is indeed linked to its relevance to *techne*; which fields are funded and which problems are pursued is influenced by political and economic forces. Erdős' prodigious collaborative approach was profoundly social as well, though he—and my father—would discount this aspect as incidental to math's knowledge claims. *Trivial*, in the way mathematicians use the word to mean true, but simple or unimportant.

I was blaspheming, a child finding contradiction and ironic fault with the Father's laws. I did not truly wish to smash the idols, though I lacked the words to explain at the time. I will invoke Donna Haraway's words now: *Blasphemy is not apostasy. Irony is about contradictions that do not resolve into larger wholes, even dialectically, about the tension of holding incompatible things together because both or all are necessary and true. Irony is about humor and serious play.* (SERIOUS PLAY® again!)

I repeated this phrase about sullying the temple to my analyst the other day in his wainscoted cerulean office across the street from the planetarium—a space where nothing is prima facie trivial, as anything is a potential portal to the unconscious—and he asked, well, *why* were you supposed to damage the idols? I would have thought the answer obvious, but I did not say so, instead sliding imperceptibly down the slippery daybed, contemplating the wind in the willow tree outside his window and fantasizing about jumping through to the leafy green world.

Later in the session he remarked, *That's why God created shrinks*.

Portal-quest narratives, such as Alice's journey to Wonderland, are often interpreted as an exploration of the unconscious. Some readers and scholars describe vivid and fearsome Freudian drama down the rabbit hole, while some, like Shattuck, offer a more anodyne interpretation:

In the middle of the Victorian era, Lewis Carroll peered into the dreamworld of an adolescent girl and found it peopled with grotesque creatures making strange demands of her good intentions. Nothing goes quite right, and nothing goes irretrievably wrong. Alice suffers no harm and wakes up having learned that the creatures within us are essentially benign under their fearsome eccentricities. Shattuck contrasts Carroll's 1865 classic with Robert Louis Stevenson's *The Strange Case of Dr. Jekyll and Mr. Hyde*, published the following year, which paints a much more dystopian vision of the world that lies within the psyche, as well as the potentially Frankensteinian consequences of scientific research.

43. Erdős was one of the greatest and most prolific mathematicians of the twentieth century. When he traveled from Budapest to Manchester, England, in 1934 at the age of twenty-one he was at a loss to eat on the train, as his mother had always buttered his bread and cut his meat for him. She often joined him on his travels until her death, and throughout his life Erdős continued to journey from conference to conference, from one mathematician's home to another, "proving and conjecturing" with a monastic ardor, widely known for his generous support toward fellow mathematicians and junior colleagues. He had no interest in romance or sex or literature—just mathematics. He collaborated with a vast network of mathematicians and contributed vitally to number theory, combinatorics, probability theory, graph theory, and many other areas, known for his conjecturing—developing new fields through questions, rather than a grand-theory top-down approach. You may have heard of the Erdős number, same principle as the Kevin Bacon number, which indicates degrees of separation based on acting in the same film; in this case, if you coauthor a paper with Erdős, your number is 1, and if you coauthor with someone who has an Erdős number of 1, then yours is 2, and so forth. The sum of your Erdős and Bacon numbers is, naturally, your Erdős-Bacon number. My father's Erdős-Bacon number is 6: 1 for Erdős plus 5 for Bacon—the first link to Bacon is another mathematician interviewed in *N is a Number,* and the last is Sarah Jessica Parker.

Since his death (two heart attacks at a math conference in Warsaw) in 1996 at age eighty-three (a prime!), Erdős has become somewhat better known outside of mathematics, partly thanks to Paul Hoffman's

1998 biography *The Man Who Loved Only Numbers* (joining *The Man Who Knew Infinity* about Ramanujan, and later joined by *The Man Who Knew Too Much* on Alan Turing). Math is so esoteric that it is exciting when it receives attention from the outside world, but often there is some diffidence about the quality of attention, such as the persistent interest in brilliant mathematicians who are mentally ill (e.g. *A Beautiful Mind*, *Proof*). Or, in Uncle Paul's case, it is this type of description, from blogger Jason Kottke: *Erdős was famously a prolific mathematician who collaborated widely…he coauthored over 1,500 papers with 500 different collaborators. He was also a homeless methamphetamine user*. The tag is absurdly sensationalized, for Erdős was never home*less*—he owned an apartment in Budapest, and he always had a roof over his head, traveling from place to place, earning honoraria and prize money (which he generally gave to causes and to support other mathematicians)—cared for by his devoted acolytes and colleagues and, in most cases, their wives. As for the amphetamines, he took them to work. A colleague, concerned for his health, once bet him that he could not quit for a month, so Erdős did quit, won the wager, and then promptly began taking them again, complaining that mathematical progress had been stalled for the course of the bet.

He wore glossy silk shirts and baggy European suits and was hunched and angular by the time I knew him. When he visited us he would arrive with a slim suitcase containing a change of clothes, notepads, pens. He stayed in my father's study and was up much of the night, talking math in his sibilant drawl, writing (math) letters to other mathematicians in his tall slanted script or listening to classical music and proving theorems.

> What is night for all beings is the time of waking for the disciplined soul. — Bhagavad Gita, II.69

> Several nights, I have seen Sri Ramanujan get up at 2 o'clock in the night and note down something in the slate in the dull light of a hurricane lamp. When my father asked him what he was writing, he used to say that he worked out mathematics in his dreams and now he was jotting the results in the slate to remember them.
> — N. Subbnarayanan, describing Ramanujan's period of work with his father, mathematician S. Narayana Aiyar, before his departure for Cambridge

Uncle Paul's English was good, if highly idiosyncratic; he had first learned it from his father, who had learned it from a book while in captivity in Siberia. At any point in a dinner conversation he could suddenly say to my father, *Let n be an integer greater than…* and they would be off in the ether, discussing mathematics in the one true world. Erdős was not entirely indifferent to this world—he had lost many relatives to the Holocaust and was ceaselessly traveling from one country to another—and could discuss history and politics with the droll pessimism shared by many of our Hungarian friends. He had developed his own lexicon: The USSR was *Joe* (Stalin) and the USA *Sam* (as in Uncle); God was always the *Supreme Fascist*—hence the most beautiful theorems were written in the *S.F.'s Book*. Women were *bosses*, men *slaves*, and children *epsilons*, after the Greek letter ε which in mathematics indicates a small number. I made a cynical existential remark at dinner once and he turned toward me, remarking, *Zee bosss ep-seeee-lon is quite cleverrrr*. Our sassy fat pug dog, Zazz, was supposed to stay out of the study when Uncle Paul was visiting, but she routinely breached the barriers (we suspected he intentionally opened the door for her) and gamboled gleefully into forbidden territory; he would amble into the kitchen with a mischievous look to report that *Zeee fascist hound has penetrated!*—and I would run in to capture her.

(We will all be together again with Zazz in the next life—this I know for sure.)

Hoffman quotes Erdős: *In a way mathematics is the only infinite human activity. It is conceivable that humanity could eventually learn everything in physics or biology. But humanity certainly won't ever be able to find everything in mathematics, because the subject is infinite. Numbers themselves are infinite. That's why mathematics is really my only interest.*

47. When I began reading post-structuralist theory and criticism in college, it pulled me—I was looking to be pulled—complementarily, which is to say both toward and away from my father and his idols. Toward them because, having been raised with integers and theorems as the bedrock of the Real, I felt ideas as present, material, and alive. I never understood the criticism of criticism on the basis of its abstraction—*that's so abstract* meant to signify *unreal*. And simultaneously pulled away because we were busy batting at the battened bulwark of certainty. Foucault's explication of *discursive practices*—his repeated demonstration that knowledge and power are inextricably interlinked, and that any attempt to decouple them is a presumptive delusion on the part of an empowered ideology seeking to naturalize its tenets. Derrida's deconstruction of phallogocentrism, the Word and the Phallus conjoined. Lacan's description of the "Law of the Father"—the established symbolic order itself. And his use of the imaginary number *i*,$\sqrt{-1}$, to denote the hapless hope to satisfy Oedipal desire which cannot be described but subtends all expression—thus the symbolic order is built upon lack. Or as the Mathemagician explains when Milo insists upon seeing the largest number there is: *The number you want is always at least one more than the number you've got, and it's so large that if you started saying it yesterday you wouldn't finish tomorrow.*

Did you follow that detour into postmodern philosophical thought? If not, then you can throw a tantrum like Alan Sokal—physicist, clever hoaxer and figure of the so-called Science Wars—who derided such theory for its putative meaninglessness. He was particularly vehement about Lacan's apparent misappropriation of mathematics, not understanding the metaphor, confusing the symbol for the real. Or you might respect that every discipline develops concepts and terminology that may appear abstruse if you presume to understand them solely on the terms of your preferred discourse. Would you criticize a mathematical equation because it is written in a language you do not understand, judging it for lack of a rhyme scheme? Or might you imagine that it carries a type of meaning and even a form of poetry which is not immediately apparent to you? What would life be without such a possibility? *Now faith is the substance of things hoped for, the evidence of things not seen*. Hebrews 11:1.

53. My father shared Norton Juster's origins—both first-generation Jewish, both born in Flatbush. My father's father was a dyspeptic accountant. His mother was a bookkeeper turned homemaker. The family, living first in Brooklyn and then in a brick row house at the end of the row in Queens Village, had arrived straight from the *shtetl*. The older uncles were sweater salesmen, born in Eastern Europe, and my grandfather instructed his two sons to follow the route he had taken—military, local college, CPA license—into the middle class. My father played stickball against the brick stoop with his younger brother and calculated batting averages for Yogi Berra, Phil Rizzuto, Mickey Mantle, and the rest of the 1950s Yankees starting lineup. When he was eight, he counted to a million during the month of April, repeating *one two three four five six seven eight nine ten* out loud ten times and then making a mark each time until he had ten thousand marks. His high-school math teacher encouraged him to apply to MIT, which may as well have been on Pluto, and that is where he landed at age sixteen, a haven where the buildings are known by numbers rather than words. My grandfather gave him four years' worth of tuition in one lump sum, so he graduated in three, moved down the road to begin graduate school at Harvard, and bought a car with the remaining cash. That summer, a friend of a friend of a friend—a Wellesley student distantly related to Laura Ingalls Wilder—invited her East Coast college circle to visit her hometown over the summer, so my father passed through the tollbooth and drove his covered wagon west into the vast new world. The chain of linking friends (3 degrees of separation) could not make the trip, but he went regardless, on his own, a skinny Ashkenazi egghead kid from Queens who had not been west of Newark now driving past hulking shaggy brown bison on the plains, drinking coffee at a truck stop diner counter between kindly stoic ranchers in cowboy hats and cowboy boots. He was frightened at the blackness of the night sky, no streetlights on the flat country roads. *The evidence of things not seen*. My father made it to Hot Springs, South Dakota—from Boston, you take I-90 west for about twenty-seven hours to Rapid City, at the foot of the Black Hills, and then turn south on Route 79 past Hermosa and Buffalo Gap—and it was there, Reader, across the Fall River viaduct, in a white clapboard house at the top of the hill, that he met my mother.

59. They raised us in a small brown shingled Victorian house—somewhat splintery and sunken into acute and obtuse angles, like a spider's legs—perched on a hill near the water on the north shore of Long Island, embracing, with what at times seemed like a sense of ironic incredulity, many of the trappings of suburban life: coaching youth soccer, which neither had ever played; music lessons, summer camp. Each morning we walked up the street to the corner and stood under the octagonal red stop sign waiting to be picked up by wheezy buses and carried to the brick elementary school named after massacred local Native Americans. My father walked with me to the bus stop on the first day of kindergarten. I see his brown 1970s-corduroy legs as we mount the hill. The oblong yellow bus arrives and I look up at the steep steps into the darkened interior, a parcel tag tied to a buttonhole on my dress with my name and my teacher's name written on it by my mother, ready for delivery.

While my father had not followed his own father's professional path (to my grandfather's eternal consternation, though my father made the all-star team in research mathematics) he had, as it turned out, followed—by way of a few intermediate stops—one of the well-trodden n^{th}–generation (where $n<3$) immigrant trails from an apartment in Brooklyn to a row house in Queens to a house on Long Island with a realio-trulio backyard. A rope hammock was strung between the white pine in the center of the yard and the maple tree along the edge. My father would lie in the hammock and think, and my brother and I would swing wildly in it, trying to launch one another through the air to tumble onto the grass. My mother gardened while my father mowed the lawn, pausing occasionally to stop, shutting off the lawnmower and scratching his belly absently—presumably with conjectures percolating in his head—before restarting the mower and continuing on. The neighbors thought him terribly lazy.

Soon after we moved in, our parents dug an irregularly shaped hexagonal sandbox together in the garden under the maple tree next to the hammock. I see my father, younger than I am now, standing in the dappled summer sun holding a shovel, pondering the geometry: consider all hexagons where the greatest distance between any two of the six vertices is, say, four feet; the one with the largest area was our sandbox—surprisingly, *not* the regular hexagon with all the same angles and same-size edges! (—proved by one of my father's colleagues, the mathematician who bet Erdős that he could not quit amphetamines for a month.) My brother and I tunneled in the sandbox with plastic dinosaurs and LEGO® figures, which, my mother reports, still surface through the soil these many years later. When we outgrew the sandbox it became an irregular hexagonal seasonal pen for patient box turtles, their own domed brown shells divided into hexagonal scutes marked by ridged orange age rings, while my brother and I moved on to the junior high school named after the local sex therapist (author of *Teenagers and Their Hangups*), followed by the high school named after the local shoe magnate.

61. Every few years during this orderly progression we picked up and moved abroad on mathematical sabbaticals, punctuating our suburban childhood with leaps to different worlds. From standing with hand over heart pledging allegiance to an American flag in a pastel cinderblock New York State public school classroom and learning cold war anti-communism lessons in social studies to singing in a concert in the Budapest Kodaly Music School choir, wearing a white blouse and red Young Pioneer kerchief. The metro on the trip to school coursing deep, deep underground, the windows open to the dark, dank tunnels, the sonorous voice of the conductor: *Moszkva tér következik—Next stop, Moscow Square.* I do not recall much curiosity on the part of our friends and teachers back home about these absences. Apparently we simply disappeared for a span of time and then reappeared, taking up where we left off.

How to describe what we had seen? One year we spent the fall in Israel, the spring in England. Our parents had some notion of exposing us to both the Jewish and Christian halves of our heritage, for we practiced neither religion. Learning the Hebrew alphabet at the table of the cool stone apartment in the city of **רְחוֹבוֹת :** a line of creatures raise their arms and feet, marching to the left. Outside we are bathed in buttery yellow light. I walk down the street to school past the rich musty orange orchard, past the bomb shelter—a concrete slab with a round opening on the side, the ladder descending into darkness—and the black shiny dogs running free which we dare not approach for fear of rabies. The school has a circular window in its front wall with no glass in it; kids sit in the well of the window watching a bonfire burn in the sandy yard. And then, mid-year, transported suddenly to rainy grey Reading, England. We live in a red brick suburban development with a miniature fenced rectangular back yard and attend Early St. Peter's Church of England primary school. Singing hymns and copying stories about Jesus from the blackboard in longhand into notebooks with thin paper covers, making colored pencil drawings of heaven and hell. I sit at the pentagonal green table nearest to the classroom door, wearing the school uniform: gray pinafore, light-blue blouse, dark-blue cardigan, dark-blue tie with diagonal gray stripes, sensible brown leather shoes. In History we are studying the Iroquois Native Americans in what is now New York State. Inside, the students are well-mannered—if you talk out of turn you are summoned to stand next to the teacher's desk, and she will slap you hard on the bare calf—but out in the schoolyard—a blacktop sea between the squat brick classroom buildings in the lee of the church—are serious and savage games. The children welcome us as novelties, call us Yanks, and cast my shy brother, gifted with an authentic American accent, as an incongruous cowboy in the school play, *Ali Baba and the Forty Thieves*.

When we lived abroad our parents read aloud to us in the evenings, all four of us together. During the year in Israel and England we read Tolkein's *The Lord of the Rings* trilogy. Each time, like the hobbits' return to Shire, we traveled from our adventure back to the same place from which we had left, each time changed by the journey.

67. My most vivid childhood memories and sensory associations are from these LANDS BEYOND. It is a blustery gray autumn day on Long Island, and I am fifteen years old, weary, walking down the hill from the bus stop after a day of clamorous high-school halls and exams under fluorescent lights (*another long afternoon*, as Milo grumbles). I am peeling a tangerine, and suddenly I stop short. Standing still on the sidewalk, holding this fluttering, delicate, tangerine, I smell orange orchards under the rich yellow Mediterranean sun. I am in Israel, and I am seven again, lying on my belly in the warm sand in the rusty playground next to the orchard, the sun resting on my back, my face close to a line of ants marching eternally toward an anthill and then through a hatch at its center, into the earth. And I want our childhood sabbatical back again—but I feel the cold November wind on my face, and I eat the tangerine as I walk the rest of the way home.

71. As I write this my parents are both the age of this twin prime. They still live in the small shingled house on Long Island where we were raised. The school bus still comes heaving up the hill each morning to collect another generation of children at the corner. Some day they will no longer be there to hear it, but they are there now. Our road is still steep and lumpy. My father taught me to ride a bicycle on Bayview Avenue, which meets our street at the 90-degree vertex of the corner bus stop. Bayview is the longer edge of the triangle, descending more gradually toward Shore Road, the ragged hypotenuse skirting the harbor. We began at the top of the hill near the corner, my father running alongside, holding the back of my seat. As I pedaled and the downward slope began to pull me away, he let me go.

73. The box turtles were temporary visitors in the irregular hexagonal pen, freed at the end of the summer. Their patterned shells made me think of the ancient Chinese Emperor Yu who was said to have come across a turtle alongside a river with markings on its back of a magic square, a grid of 3x3 in which the numbers of each row, column, and diagonal add up to the same sum. One August day, we took Beethoven the turtle (who may still be alive, if not waylaid by more imprudent children—box turtles can live to ~100 years) out to roam around the yard a bit after a lunch of strawberries and raw hamburger meat. He made his way slowly but purposefully to the white pine in the center of the yard, buried his head in a tuft of grass at its base and then lay still. We laughed at him, thinking he was hiding from us by hiding his head. But then we went inside for dinner, forgetting about Beethoven, and when we came out again he was gone.

79. My father does not regret that I did not become a mathematician. He has always wanted me to find my own path into the world. His Book is different from mine, but it is also the same. His faith is different from mine, but it is also the same. *That was his way of looking, different from hers. But looking together united them*. (Virginia Woolf, *To the Lighthouse*.) I cannot decipher his cryptic symbols drawn in ballpoint pen on notepaper pads scattered throughout the house—nor does he necessarily understand the languages I have learned—but we write our eights the same odd way, the two circles drawn separately, sometimes nestled together and sometimes floating apart. They are the longest eights you have ever seen.

At times I crave the certainty of mathematical proof. I miss the atomic solidity of prime numbers. But I was raised with them, after all, and I carry them with me in my own way. I carry my father's belief in the Platonic reality of integers in my own way as well—as a belief in different ways of looking held up side by side; in Keats' negative capability; in Derridean supplementarity; in the principle of complementarity *and* proof by contradiction both. As Adam Gopnik describes his mentor Kirk Varnedoe's last art history lecture, given shortly before his death:

> Then he began to talk about his faith. "But what kind of faith?" he asked. "Not a faith in absolutes. Not a religious kind of faith. A faith only in possibility, a faith not that we will know something, finally, but a faith in not knowing, a faith in our ignorance, a faith in our being confounded and dumbfounded, as something fertile with possible meaning and growth. …Because it can be done, it will be done. And now I am done."

83. Are we there yet? Later in their voyage Milo and Tock travel unwittingly to the Island of Conclusions, wondering how they arrived. Their new acquaintance Canby explains that *"every time you decide something without having a good reason, you jump to Conclusions whether you like it or not." "But this is such an unpleasant-looking place,"* Milo replies, to which Canby readily assents: *"Yes, that's true…it does look much better from a distance."*

Milo and Tock do not stop there, but venture further. Ultimately Milo succeeds in his quest to reconcile King Azaz and the Mathemagician, establishing the validity of both words and numbers and restoring harmony to the Land of Wisdom before he drives back through the purple tollbooth and into his bedroom. That night he sleeps deeply and soundly, looking forward to more adventures. (I still picture the tollbooth sitting in the middle of the square red carpet of my own childhood bedroom where my father first read me this story.) The next day, however, Milo returns home from school and is dismayed to discover that the tollbooth has disappeared. He finds a bright blue envelope in its place containing the following note: *It's true that there are many lands you've still to visit (some of which are not even on the map) and wonderful things to see (that no one has yet imagined), but we're quite sure that if you really want to, you'll find a way to reach them all by yourself.*

89. In 2013, Yitang Zhang, an impassive and reclusive unpublished fifty-eight-year-old adjunct lecturer at the University of New Hampshire who had been toiling in obscurity for years (including a stint working at a Subway shop) shook the math world by proving that there are an infinite number of gaps *smaller* than 70,000,000 between successive primes—the first finite bound ever proven. It is a Ramanujan-esque story of unsung genius, much more improbable than you might think; for one reason, as Hardy explained: *I do not know of an instance of a major mathematical advance initiated by a man past fifty* (though Hoffman points out that Erdős became a notable counter-example).

Born in Shanghai in 1955, Zhang moved to the US to complete a PhD in mathematics at Purdue University but left Indiana without any job prospects. Perhaps attempting to justify his lack of assistance in helping Zhang secure a tenure-track post, Zhang's thesis advisor T. T. Moh later described him as *a disturbing soul, a burning bush, an explorer who wanted to reach the north pole, a mountaineer who determined to scale Mt. Everest, and a traveler who would brave thunders and lightnings* [sic] *to reach his destination. [...] I regarded him as a free spirit, and I should let him fly.*

Several decades later Zhang's breakthrough on the prime gaps problem came when he was standing in a friend's backyard, smoking a cigarette and hoping to spy some deer. The deer never arrived, but he had a vision, seeing the key to the theorem in his mind's eye. He returned to the house, following the apparition toward a proof of a conjecture which had stumped mathematicians for thousands of years. *There are many deer sometimes*, Zhang explained later. *I didn't see any deer, but I got the idea.*

Zhang has since moved west to a tenured professorship in California, and through the work of the collaborative Polymath Project the gap has been lowered—at the time of this writing—to 246. If it reaches 2, the twin prime conjecture will be solved, another page of The Book revealed!

97. The moral of the story is this: keep driving. Travel to the next prime, and then the next. The farther away from home you journey, the closer you will be to home. The distances between stops will become longer, though now we know there will always be shorter gaps as well, warmly lit late-night truck-stop counters where you can sit and eat a slice of apple pie next to kind stoic men in cowboy hats. Now return to your car and keep going. The darkness of the night sky between the stars and the darkness of the road will stun you calm. When you have voyaged far enough, the means by which you have traveled—by numbers, by words, by faith, by logic, by work, by family, by love—and the means by which you can explain it will cease to matter, for you will be beyond matter.

101. Ursula Le Guin: *As for the fish of the sea, their names dispersed from them in silence throughout the oceans like faint, dark blurs of cuttlefish ink, and drifted off on the currents without a trace.*

103. Or as my father once told his class of young mathematicians, *It's kind of a nice feeling just to drift out to infinity.*