THINKING

IN

NUMBERS

On Life, Love, Meaning, and Math

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Fourteen

THE ADMIRABLE NUMBER PI

To believe the poet Wisława Szymborska, I am one in two thousand. The 1996 Nobel laureate offers this statistic in her poem "Some Like Poetry" to quantify the "some." Actually I think she is a tad too pessimistic—I am hardly as rare a reader as that. But I can see her point. Many people consider poetry to be all clouds and buttercups, without purchase on the real world. They are right and they are wrong. Clouds and buttercups exist in poetry, but they are there only because storms and flowers populate the real world too. Truth is, a good poem can be about anything.

Including numbers. Mathematics, several of Szymborska's verses show, lends itself to poetry. Both are economical with meaning; both can create entire worlds within the space of a few short lines. In "A Large Number," she laments feeling at a loss with numbers many zeroes long, while her "Contribution to Statistics" notes that "out of every hundred people, those who always know better: fifty-two" but also, "worthy of empathy: ninety-nine." And then there is "The Admirable Number Pi," my favorite poem. It—the poem, and the number—begins: three point one four one.

Once, in my teens, I confided my admiration for this number to a classmate. Ruxandra was her name. Like the poet's, her name came from behind the Iron Curtain. Her parents hailed from Bucharest. I knew nothing of Eastern Europe, but that did not matter: Ruxandra liked me. She liked that I was quite different from the other boys. We spent breaks between lessons in the school library, swapping ideas about the future and homework tips. Happily for me, her strongest subject was math.

In a moment of curiosity, I asked about her favorite number. Her reply was slow; she seemed not to understand my question. "Numbers are numbers," she said.

Was there no difference at all for her between the numbers 333, say, and fourteen? There was not.

And what about the number pi, I persisted—this almost magical number that we learned about in class. Did she not find it beautiful?

Beautiful? Her face shrank with incomprehension.

Ruxandra was the daughter of an engineer.

The engineer and the mathematician have a completely different understanding of the number pi. In the eyes of an engineer, pi is simply a value of measurement between three and four, albeit fiddlier than either of these whole numbers. In his calculations he will often bypass it completely, preferring a handy approximation like 22/7 or 355/113. Precision never demands of him anything beyond a third or fourth decimal place (3.141 or 3.1416, with rounding). Digits past the third or fourth decimal do not interest him; as far as he is concerned, it is as though they do not exist.

Mathematicians know the number pi differently, more intimately. What is pi to them? It is the length of a circle's round line (its circumference) divided by the straight length (its diameter) that splits the circle into perfect halves. It is an essential response to the question, "What is a circle?" But this response—when expressed in digits—is infinite: the number has no last digit, and therefore no next-to-last digit, no antepenultimate digit, no third-from-last digit, and so on. One could never write down all its digits, even on a piece of paper as big as the Milky Way. No fraction can properly express pi: every earthly calculation produces only deficient circles, pathetic ellipses, shoddy replicas of the ideal thing. The circle that pi describes is perfect, belonging exclusively to the realm of the imagination.

Moreover, mathematicians tell us, the digits in this number follow no periodic or predictable pattern: just when we might anticipate a six in the sequence, it continues instead with a two or zero or seven; after a series of consecutive nines, it can as easily remain long-winded with another nine (or two more nines or three) as switch erratically between the other digits. It exceeds our apprehension.

Circles, perfect circles, thus enumerated, consist of every possible run of digits. Somewhere in pi, perhaps trillions and trillions of digits deep, a hundred successive fives rub shoulders; elsewhere occur a thousand alternating zeroes and ones. Inconceivably far inside the random-looking morass of digits, having computed them for a time far longer than that which separates us from the big bang, the sequence 123456789...repeats 123,456,789 times in a row. If only we

could venture far enough along, we would find the number's opening hundred, thousand, million, billion digits immaculately repeated, as though at any instant the whole vast array were to begin all over again. And yet, it never does. There is only one number pi, unrepeatable, indivisible.

Long after my schooldays ended, pi's beauty stayed with me. The digits had insinuated themselves into my mind. Those digits seemed to speak of endless possibility, illimitable adventure. At odd moments I would find myself murmuring them, a gentle reminder. Of course, I could not possess pi—the number, its beauty, or its immensity. Perhaps, in fact, it possessed me. One day, I began to see what this number, transformed by me, and I by it, could turn into. It was then that I decided to commit a multitude of its digits to heart.

This was easier than it sounds, since big things are often more unusual, more exciting to the attention, and hence more memorable than small ones. For example, a short word like *pen* or *song* is quickly read (or heard), and as quickly forgotten, whereas *hippopotamus* slows our eye (or ear) just enough to leave a deeper impression. Scenes and personalities from long novels return to me with far greater insistence and fidelity, I find, than those that originated in short tales. The same goes for numbers. A common number like thirty-one risks confusion with its common neighbors, like thirty and thirty-two, but not 31,415 whose scope invites curious, careful inspection. Lengthier, more intricate digit sequences yield patterns and rhythms. Not 31, or 314, or 3141, but 3 1 4 1 5 sings.

I should say that I have always had what others call "a good memory." By this, they mean that I can be dependably relied upon to recall telephone numbers, dates of birthdays and anniversaries, and the sorts of facts and figures that crowd books and television shows. To have such a memory is a blessing, I know, and has always stood me in good stead. Exams at school held no fear for me; the kinds of knowledge imparted by my teachers seemed especially amenable to my powers of recollection. Ask me for the third person subjunctive of the French verb "être," for instance, or better still the story of how Marie Antoinette lost her head, and I could tell you. Piece of cake.

Pi's digits henceforth became the object of my study. Printed out on crisp, letter-size sheets of paper, a thousand digits to a page, I gazed on them as a painter gazes on a favorite landscape. The painter's eye receives a near infinite number of light particles to interpret, which he sifts by intuitive meaning and personal taste. His brush begins in one part of the canvas, only to make a sudden dash to the other side. A mountain's outline slowly emerges with the tiny, patient accumulation of paint. In a similar fashion, I waited for each sequence in the digits to move me—for some attractive feature, or pleasing coincidence of "bright" (like 1 or 5) and "dark" (like 6 or 9) digits, for example, to catch my eye. Sometimes it would happen quickly, at other times I would have to plow thirty or forty digits deep to find some sense before working backward. From the hundreds, then thousands, of individual digits, precisely rendered and carefully weighed, a numerical landscape gradually emerged.

A painter exhibits his artwork. What was I to do? After three months of preparation, I took the number to a museum, the sprawling digits tucked inside my head. My aim: to set a European Record for the recitation of pi to the greatest number of digits.

March is the month of spring showers, and school holidays, and spick-and-span windows. It is also the month when people the world over celebrate "Pi Day," on March 14. So on that day, in 2004, I traveled north from London to the city of Oxford, where staff members at the university's Museum for the History of Science were waiting for me. Journalists, too. An article in the *Times*, complete with my photo, announced the upcoming recitation.

The museum lies in the city center, in the world's most ancient surviving purpose-built museum building, the Old Ashmolean. Iconic stone heads, wearing stone beards, peer down at visitors as they pass through the gates. The thick walls are the color of sand. Approaching the building, photographers appear as if from nowhere, holding cameras, like masks, up to their faces. The piercing flashes momentarily petrify my expression. I stop and raise my features into a smile. A minute later they are gone.

The record attempt's organizers have occupied the museum building. Television camera wires snake the length of the floor. Posters requesting donations (the event is raising money for an epilepsy charity, at my request, since I suffered from seizures as a young child) dress the walls. A table and chair, I see on entering, have already been set out for me on one side of the hall. Before it, a longer table awaits the

mathematicians who will verify my accuracy. But there is still an hour before the recitation is due to start, and I find only a trio of men talking together. One has a full head of wiry hair, one has a multicolored tie, and one has neither hair nor tie. The third steps briskly forward and introduces himself as the main organizer, and the others as the museum's curator and his assistant. Their faces show mild puzzlement, curiosity, and nerves. Shortly afterward, reporters arrive to hold the microphones and man the television cameras. They film the display cases containing astrolabes, compasses, and mathematical manuscripts.

Someone asks about the blackboard that hangs high on the wall opposite us. The curator explains that on May 16, 1931, Albert Einstein used it during a lecture. What about the chalky equations? They show the physicist's calculations for the age of the universe, replies the curator. According to Einstein, the universe is about ten, or perhaps one hundred, thousand million years old.

Footfalls increase on the museum's stone steps as the hour approaches. The mathematicians duly arrive, seven strong, and take their seats. Men, women, and children keep coming; it is soon standing room only. The air in the hall grows thick with hushed talk.

At last, the organizer calls everyone to silence. All eyes are on me; nobody moves. I sip a mouthful of water and hear my voice begin. "Three point one four one five nine two six five three five eight nine seven nine three two three eight four …"

My audience is only the second or third generation able to hear the number pi beyond the first few tens or hundreds

of decimal places. For millennia it existed only in a breathful of digits. Archimedes knew pi to only three correct places; Newton, almost twenty centuries later, managed sixteen. Only in 1949 did computer scientists discover pi's thousandth digit (following the decimal point): nine.

It takes about ten minutes, at a rate of one or two digits per second, for me to reach this nine. I do not know how long exactly; an electronic clock records the seconds, minutes, hours of the recitation for the public to watch, but I cannot see it from my chair. I stop reciting to sip water and catch my breath. The pause feels palpable. Dolorous even. I feel completely, oppressively alone.

The rules for the recitation are strict. I cannot step away from the desk, except to use the bathroom, and then always accompanied by a member of the museum's staff. No one may talk to me, not even to cheer me on. I can stop reciting momentarily to eat fruit or a piece of chocolate, or drink, but only at pre-agreed intervals a thousand digits apart. Cameras record my every sound and gesture.

"Three eight zero nine five two five seven two zero one zero six five four …"

An occasional cough or sneeze from the audience punctuates the flow of digits. I do not mind. I meditate on the colors and shapes and textures of my inner landscape. Calmness gains on me; my anxiety falls away.

Most of the spectators know nothing of Archimedes' polygons; they have no idea that the ten digits they have just heard will eventually repeat an infinite number of times, have never thought of themselves as being in any way susceptible to

math. But they listen attentively. The concentration in my voice seems to communicate itself to them. Faces, young and old, round and oval, all wear delicate frowns. Listening to the digits, they hear their dress sizes, their birthdays, their computer passwords. They hear excerpts—both shorter and longer—from a friend's, or parent's, or lover's telephone number. Some lean forward in expectation. Patterns coalesce, and as quickly disperse, in their minds.

The people are all different. They have various motives for being here, and various goals. A teenager finds in the hall a hideout from his Sunday boredom; a manual laborer, having donated the equivalent of a pack of cigarettes in salary, sticks around to get his money's worth; an American tourist in shorts and a Mickey Mouse hat cannot wait to recount the spectacle to her family.

An hour passes, and then another.

"Zero, five, seven, seven, seven, seven, five, six, zero, six, eight, eight, eight, seven, six..."

I head further and further inside the number, exhaling effort, rhythm, and precision with every breath. The decimals exhibit a kind of deep order. Fives never outstrip sixes for long, nor do the eights and nines lord it over the ones and the twos. No digit predominates except for brief and intermittent instants. Every digit, in the end, has more or less equal representation. Every digit contributes equally to the whole.

Halfway through the recitation, more than ten thousand decimals in, I stop to stretch. I push back the chair, stand and shake out my limbs. The mathematicians put down their sharp pencils and wait. I bring a bottle to my lips and

swallow the plastic bottle-tasting water. I eat a banana. I fold my legs, resume my position at the desk, and continue.

The silence in the hall is total. It reigns like a tsar. When a young woman's mobile telephone suddenly starts up, she finds herself promptly ejected.

Despite such rare commotions, a sly complicity establishes itself between the public and me. This complicity marks a vital shift. At the beginning, the men and women beamed confidence, listening expectantly, and taking pleasure in the digits' familiar sounds as those shoe sizes, historical dates, and car registration plates reached their ears. But, slowly, imperceptibly, something changed. Consternation grew. They could not follow the rhythm of my voice, they realized, without making continuous minor adjustments. Sometimes, for example, I recited the digits fast, and at other times I recited them slow. Occasionally, I recited in short bursts interleaved with pauses; at other moments, I recited the digits in a long, unbroken phrase. Sometimes the digits sounded thinly, accented by some inner agitation in my voice; instants later, they would soften to a clear and undulating beat.

Consternation now turns increasingly to curiosity. More and more, I feel the timing of their breathing coincide with mine. I sense their raw intrigue at the sound and sweep of every digit as it passes and makes way for the next. When the digits darken in my mouth—heavy eights and nines packed together—the tense distant faces grow tenser still. When a sudden three emerges from a series of zeroes and sevens, I hear something like a faint collective pant. Silent nods greet my accelerations; warm smiles welcome my slowdowns.

Between the moments when I stop reciting to sip water or take a bite, and continue reciting, I hardly know where to look. My solitude is absolute; I do not want to return the people's stares. I look down at the shadows of bones and veins in my hands, and at the scuffs in the wooden desk on which they rest. I notice the glimmers of shiny metal that dapple the display cases. On a cheek, here and there, I cannot help noticing, tears.

Perhaps the experience has taken the audience by surprise. No one has told them that they will find the number tangible, moving. Yet they succumb gladly to its flow.

I am not the first person to recite the number pi in public. I know there are a few "number artists"—men who recount numbers as actors recall their scripts. Japan is the center of this tiny community. In Japanese, spoken digits can sound like whole sentences; pronounced a certain way, the opening digits of pi, 3.14159265, mean "An obstetrician goes to a foreign country." The digits 4649 (which occur in pi after 1,158 decimal places) sound just like "nice to meet you," while a Japanese speaker pronouncing the digits 3923 (which occur after 14,194 decimal places) simultaneously says, "Thank you, brother."

Of course, such verbal constructions always suffer from arbitrariness. The short, stiff phrases stand apart, with only the speaker's ingenuity to splice them together. Japanese spectators, I have heard, watch these men perform as they might watch a tightrope walker; listening only in case of a blunder, as others watch only in case of a fall.

The relationship these artists have with numbers is com-

plicated. Many years of repetitive learning hone their technique; but they also produce a nagging feeling of duplicity: repeated numbers (and words) often finish by losing all their sense. It is not uncommon, after each public display, for the performer to impose a monthslong fast of every digit. Benumbed by numbers, even a price tag, a barcode, an address, sickens him.

In the number artist's brain, pi can be reduced to a series of phrases. In my mind, it is I, not the number, who grows small. I diminish myself as much as possible before the mystery of pi. Emptying myself, I perceive every digit up close. I do not wish to fragment the number; I am not interested in breaking it up. I am interested in the dialogue between its digits; in the unity and continuity that underlie them all.

A bell cannot tell time, but it can be moved in just such a way as to say twelve o'clock—similarly, a man cannot calculate infinite numbers, but he can be moved in just such a way as to say pi.

"Three, one, two, one, two, three, two, two, three, three, one..."

Reciting, I try to summon up a true picture of what I see and feel. I want to convey the shapes, and colors, and emotions that I experience, to everyone in the hall. I share my solitude with those who watch and listen to me. There is intimacy in my words.

A third hour comes and goes; the recitation enters its fourth hour.

More than sixteen thousand decimal places have escaped

my lips. Their swelling company presses me on. But exhaustion also grows within my body, and all of a sudden my mind goes blank. I feel the blood falling out of my head. Up until only a few moments ago the digits had accompanied me; now they make themselves scarce.

In my mind's eye, ten identical-looking paths stretch out before me; each path leading on to ten more. One hundred, a thousand, ten thousand, one hundred thousand, a million paths, beckon me out of the impasse. They stream in every possible direction. Which way to go? I have no idea.

But I do not panic. What good did panicking ever do anyone? I shut my eyes tight, and coaxingly rub the skin around my temples. I take a deep breath.

Green-tinted blackness pervades my mind. I feel disoriented, lost. A filmy white surfaces over the black, only to be recovered by a rolling gray-purple. The colors bulge and vibrate but resemble nothing.

How long did these maddening misty colors last? Seconds, but they each seemed agonizingly longer.

The seconds pass indifferently; I have no choice but to endure them. If I lose my cool, all is finished. If I call out, the clock comes to a halt. If I do not give the next digit in the next few moments, my time will be up.

No wonder the next digit, when finally I release it, tastes even sweeter than the rest. This digit requires all my force and all my faith to extract it. The mist in my head lifts, and I open my eyes. I can see again.

The digits flow fleet and sure, and I regain my composure. I wonder if anyone in the hall noticed a thing.

"Nine, nine, nine, nine, two, one, two, eight, five, nine, nine, nine, nine, nine, three, nine, nine..."

Quickly, quickly, I must keep going. I must not let up. I cannot linger, not even before the most outstanding glimpses of the number's beauty; the joy I feel is subordinate to the need to reach my goal and recite the final digit in my mind. I must not disappoint all who are standing here, watching me and listening to me, waiting for me to bring the recitation to its fitting conclusion. All the preceding thousands have no value in themselves: only once I have wrapped everything up can they successfully count.

Five hours have now elapsed. My speech begins to slur; I am drunk on exhaustion. The end is in sight, but it generates fear: am I up to it? What if I fall short? Tension stirs me for this culminating burst.

And then, minutes later, I say, "Six, seven, six, five, seven, four, eight, six, nine, five, three, five, eight, seven," and it is over. There is nothing more to say. I have finished recounting my solitude. It is enough.

Palms come together; hands clap. Someone lets out a cheer. "A new record," someone else says: 22,514 decimal places. "Congratulations."

I take a bow.

For five hours and nine minutes, eternity visited a museum in Oxford.