

DONALD COXETER: THE MAN WHO SAVED GEOMETRY

SIOBHAN ROBERTS

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White flashes lit up the splendidly restored auditorium of Hungary's Academy of Sciences in Budapest, on the east bank of the Danube River. Photographers, who don't usually show up at math conferences, attended this one in late July to get pictures of Ferenc Madl, the Hungarian president, making a rare public appearance. On this occasion, however, the head of state had to share the stage. The legendary Donald Coxeter, a 95-year-old professor emeritus from the math department at the University of Toronto and member of London's Royal Society, was delivering a paper to kick off the event. And no one, not even the paparazzi, could take their eyes off him: with his birdlike profile and receding halo of white hair, he inched his way toward the lectern, leaning only slightly on his cane. Wearing a three-piece suit and a gold turtle brooch pinned to his lapel (an acknowledgement of his turtlelike pace), he looked more like an Edwardian gentleman than a mastermind professor.

Donald Coxeter is the greatest living classical geometer. His work has had significant impact in the worlds of chemistry, physics, computer programming and medical research. Buckminster Fuller's iconic geodesic dome design was influenced by Coxeter, and M.C. Escher relied heavily on Coxeter's theories for his famous Circle Limit drawings. But Coxeter's greatest achievement, the one for which he will be remembered generations from now, was that he almost single-handedly saved classical geometry from extinction.

You might think the loss of geometry — like the loss of, say, Latin — would pass virtually unnoticed. This is the thing about geometry: we no more notice it than we notice the curve of the earth. To most people, geometry is a grade school memory of fumbling with protractors and memorizing the Pythagorean theorem. Yet geometry is everywhere. Coxeter sees it in honeycombs, sunflowers, froth and sponges. It's in

the molecules of our food (the spearmint molecule is the exact geometric reflection of the caraway molecule), and in the computer-designed curves of a Mercedes-Benz. Its loss would be immeasurable, especially to the cognoscenti at the Budapest conference, who forfeit the summer sun for the somnolent glow of an overhead projector. They credit Coxeter with rescuing an art form as important as poetry or opera. Without Coxeter's geometry — as without Mozart's symphonies or Shakespeare's plays — our culture, our understanding of the universe, would be incomplete.

Coxeter managed the Budapest trip, even though he knows he is close to the end of his life. He has arranged to donate his brain to a team of neuroscientists at McMaster University, the same group that studied Einstein's three years ago. The gathering in Budapest might well have been this intellectual titan's last journey out into the world he has spent most of the past century measuring.

At the lectern, Coxeter took his time getting started, positioning his diagrams, checking the order of the pages of his talk ("An Absolute Property of Four Mutually Tangent Circles"), holding in suspense an audience of 300, many of whom wondered if the man still had anything left to teach. Minutes into his talk, a rumble of unease arose in the rear: Coxeter's microphone wasn't working, but neither was his hearing aid. "Louder — we can't hear!" cried his 61-year-old daughter, Susan. A retired nurse, she has accompanied him on all his trips since 1999, when her mother, Rien, died after several years with Alzheimer's. Susan was sitting far from the stage, as she always does; once her father gets rolling, she usually buries her head in a novel. Coxeter, oblivious to her cries, carried on, twirling between his fingers a geometric prop, a cube constructed from a nexus of multicoloured straws.

The model was constructed for him by Glenn Smith, a hobby geometer from Texas who makes his living in the sesame seed business. Here's how he explains the importance of geometry: "I told my kids when they were young that you should learn geometry, because if you're ever picked up by a flying saucer you need to be able to make a tetrahedron like this." Smith placed his right hand on his forehead and his left on his right elbow. "Do that, and they'll know you have some intelligence."

Coxeter's own definition of geometry is simple: "It's the study of figures, as in shapes, and figures, as in numbers." But his work goes well beyond triangles and circles. He concentrates on shapes that can't exist in three dimensions, forms that are so complicated they sometimes can't even be drawn, only described mathematically. He has

such exceptional geometric intuition that he can often see these perfectly symmetrical shapes in his mind's eye before he works out the proof.

Among mathematicians, he is best known for discovering concepts (now called Coxeter groups and Coxeter diagrams) that determine how shapes will behave — and how many symmetries they will generate — when repeatedly reflected, as in a kaleidoscope. You can think of these concepts as something like Internet plug-ins: they allow a crude operating system (the brain) to interface with a higher medium (say, four- or five-dimensional space). Significantly, they help the field of classical geometry mingle more effectively with algebra. At the conference in Budapest, one overhead projection after another was filled with high-math hieroglyphs of his discoveries. Astonishingly, the references span the past six decades.

Donald Coxeter was born in 1907, and raised in a house just outside London, England, that was filled with art and music. His father, Harold, had a solid baritone voice and a passion for sculpture but unwillingly became the “Son” in Coxeter & Son, a family business that manufactured surgical instruments. (The company invented a mechanism for anaesthetizing patients with a continuous and controlled flow of oxygen and laughing gas.) Harold sometimes invited other amateur musicians over to the house, and it was one of those friends who taught young Donald to play the piano. Donald's mother, Lucy Gee, was a visual artist. One of six portraits she painted of her son, depicting him at age three seated at the piano, now hangs in the master's lodge at Trinity College, Cambridge.

Donald was an only child and never really outgrew his affable but essentially asocial nature. His father once jokingly remarked: “You can't talk to Donald about much but music or math.” For Donald, those subjects were vast universes. He composed piano pieces, a string quartet and, when he was 12, an opera. His interest in math, which developed early and inexplicably, was just as profound: at three, he began staring at the financial pages of London's Daily Mail, because that was the only place in the paper where he could find a preponderance of numbers.

Donald also created his own language, Amellaibian — a cross between Latin and French — and filled a 126-page notebook with information on the imaginary world where it was spoken. Written entirely in impeccable upper-case letters, the book contains vocabulary lists (“The Teminations of Amellaibian Words,” neatly divided into verbs, nouns and pronouns, adjectives and adverbs), maps, histories, genealogies, short stories and a section called “Fairies' Birthdays and Other

Events.” Pages and pages are dedicated to weights and measures, formulas, equations and Amellaibian magic numbers (any that factored into Donald’s favourite number, 250).

While Donald focused on his fairy-tale world, his parents were drifting apart. In 1919, Harold and Lucy sent him off to St. George’s School in Harpenden, 20 kilometres north of London, to shield him from the divorce. Though he was miserable there (“I was incarcerated at boarding school,” he recalls), it was at St. George’s that he had his formative encounter with geometry. Convalescing in the school infirmary with the chicken pox, he found himself lying next to John Flinders Petrie, son of the Egyptologist and adventurer Sir William Matthew Flinders Petrie. The two began chatting about why there were only five Platonic solids and passed the time contemplating the possibility of others. A few years later, Donald won a school prize for an essay on how to project shapes into higher dimensions — “Dimensional Analogy,” he called it.

His father decided Donald deserved a more challenging educational environment and took the boy, along with his prize-winning essay, to Bertrand Russell. Fellow pacifists, Russell and Harold had met in London during the war at a conscientious objectors meeting. Russell concluded that Donald was brilliant and asked one of his friends to write to E.H. Neville, the mathematician who had helped bring the self-taught numerical genius Srinivasa Ramanujan from India to study at Cambridge. The letter read, in part: “A certain Donald Coxeter, aged 15, who is supposed to be a rather unusual mathematician and musician for his years, has spent his summer holiday writing what I am told is an entirely original treatise on the fourth dimension. . . I have heard a great deal about him and know that he does not get any real sympathy or understanding at school in his mathematical pursuits. I think you will forgive me for sending him word he may write to you and ask you to help him. . .” Neville met with Donald, deemed his school inadequate and suggested that he drop all subjects save math and German (the best mathematicians were German) and be fast-tracked by private tutelage for Cambridge. (Once Coxeter found a suitable tutor, he still had to catch up on some fundamentals, so he was instructed “No work in the fourth dimension, except Sundays.”)

In 1926, he went off to Cambridge with a scholarship, and a substantial supply of homemade marzipan from his mother. She also arranged for her scrawny son to receive an extra glass of milk each night before bed. And when he became ill one term with a duodenal ulcer, she got permission to stay in his residence at Trinity College to look after him. She was said to be the only woman at that point, save Queen Victoria, who had ever slept over at Cambridge.

Coxeter flourished at university. In 1929, he earned his BA, and two years later received his Ph.D., as well as the coveted Smith's Prize for the best essay on a mathematical topic. He also found a wife, Rien Brouwer. She lived in Holland but was introduced to him on holiday by a family friend, a Dutch baroness married to an Englishman. Coxeter wooed Brouwer with visits to the stables where he kept his horse, Trixie (purchased with leftover fellowship money). When he saw her ride bareback, he was smitten. The feeling was mutual; she moved to Cambridge during his final year.

After graduation, Coxeter did a stint at Princeton on a Rockefeller Foundation fellowship. He went back and forth between New Jersey and Cambridge until 1936, when the University of Toronto invited him to give a talk. A year later, U of T offered him an assistant professorship, and he accepted. Math jobs in Britain were hard to come by just after the Depression, and Harold, who foresaw war clouds brewing again in Europe, had encouraged his son to say yes.

That was Coxeter's last conversation with his father. Days before he and Rien were married, Harold was swimming in the English Channel, had a heart attack and drowned. In the wedding pictures, you can see Coxeter's hands tightly clenched into white fists. The young couple left England that same year (to the dismay of his mother, who stayed behind) and moved to Toronto. They've been here ever since, despite the fact that it took seven years for Coxeter to be elevated to associate professor and another five before he got tenure. "I felt like the patriarch Jacob," he says, "working seven years for Leah and seven years for Rachel."

In the 1940s, the U.S. government invited him to serve as a code breaker, but being a Quaker and a pacifist, like his father, he declined. (Coxeter was among those who in 1997 marched a petition to the president's office at U of T to protest an honorary degree being conferred on George Bush Senior. Coxeter remembers Robert Prichard telling him, "Donald, I have more important things to worry about.")

Coxeter rose in the academic ranks, and in the mid-1950s purchased a home on Roxborough Drive for \$3,750. He and his wife raised two children there: Edgar — a former minister, now 63 and living in upper New York state — and Susan. (Today, there are six grandchildren and six great-grandchildren). The couple had come a long way from their first years in Canada, when they were so conscious of hot water bills that they'd share the same bathwater — Rien first, then Donald.

Rien loved the ivory tower social scene; he could barely tolerate it. She had ambitions for her husband to become head administrator in the math department and made it her business to keep him on track

(he had no interest in the position and never got it). She dressed him smartly in windowpaned suits with matching diagonally checked ties; prompted him to wipe his nose when it was dripping (as it still chronically does); and prodded him into talking to powerful people at parties. They entertained regularly, though he often found it awkward: he would fumble hopelessly with the back zipper of his wife's dress while the doorbell was ringing. On one occasion, Coxeter incorrectly lowered the digestif tray down the dumb waiter, and everything, including the sherry bottle and glasses, crashed and shattered.

When things were quiet, Coxeter loved his house and filled it with such monstrously named geometric models as the "Great Dirhombicosidodecahedron" and the "Snub Dodecadodecahedron" — spherical creations roughly the size of large cantaloupes but spiky and multi-coloured, like wildly mutated Rubik's cubes. The dining-room table was where he did much of his work at home — and still does. To this day, it's covered with academic papers and math queries. He sits among them most afternoons, reading with a magnifying glass. The latest addition is a recently compiled bibliography of his nearly 250 published works, which include 12 books and innumerable papers with such poetic titles as "Whence Does an Ellipse Look Like a Circle?" At night, he heads off to bed with a cocktail of Kahlúa, peach schnapps and soy milk.

Susan moved into the house three years ago, after her mother died, to help her father with his daily routine. She patiently accompanies him on his walks to Mount Pleasant and back, with her two cairn terriers in tow. (Despite his waning strength, he regularly pushes himself up the hilly 100 yards.) Susan does, however, sometimes tire of constantly hearing about math. She understands her father's iconic status but not his work. After his talk in Budapest, she commented, "To think we've come all this way to talk about circles touching circles when there are so many more important things going on in the world. Dad would hate to be equated with Elvis Presley, but Elvis gave people some moments of joy, happiness, inspiration. And if that's what Dad's work does for these people, that's wonderful. Personally," she added, "I get more from Elvis Presley."

While Coxeter delivered his Budapest lecture, people in every row could be seen scribbling notes and copying diagrams. At the end of the day, there was a reception, a buffet-style meal without tables or chairs. Mathematicians milled about in the ballroom and scrounged for desserts among a miscalculated supply. Coxeter found the sole bank of seats, a majestic row on a raised mahogany platform, and carefully

lowered himself. Like a king presiding over his court, he sat at the centre of a constant rotation of visitors and well-wishers.

Ernest Vinberg from Moscow State University introduced himself and thanked Coxeter for long ago writing a letter to Vinberg's Soviet-era Ph.D. committee, reassuring them that his field of study wasn't politically suspect. Daina Taimina from Latvia told Coxeter his *Introduction to Geometry* saved her when she started teaching high school geometry in 1975. "I still use your books today," she said. John Radcliffe from Vanderbilt University in Nashville told Coxeter he had one copy of his *Regular Complex Polytopes* at work and another in his study at home for late-night consultations. "This is the modern-day Euclid's *Elements*," Radcliffe said, pulling a copy from his briefcase. "It's like the Bible to me. I refer to it all the time."

These were just some of the books that played a role in saving classical geometry from its near demise. The saga goes like this: In the mid-20th century, there was a philosophical shift in mathematics led by a practitioner named Nicolas Bourbaki, a Frenchman whose works were read and quoted extensively but who hadn't yet made a public appearance. He argued that classical geometry (using shapes) was a thing of the past and that analytic geometry (more like algebra, with equations and numbers) was the way of the future.

The mathematics community was buzzing with rumours about who this heretic was when it was revealed that Nicolas Bourbaki did not actually exist; the name was a pseudonym under which several young scholars, mostly French, had united. The anonymous Bourbaki society was formed in the mid-1930s by a small group of mathematicians from the Ecole Normale Supérieure who were dissatisfied with the courses they were teaching. (They had borrowed the name from an actor who performed comic sketches involving math gibberish and had himself borrowed the name from a failed French general.)

The Bourbakis — whose motto was "Down with Euclid! Death to the triangles!" — wrote treatises on how to reform math. To the surprise of everyone involved, the booklets became a huge commercial success. The Bourbaki polemic spread from France to England and across the Atlantic to North and South America (Asia and the socialist countries of Eastern Europe hung on to the classical model). Its popularity can be explained by geopolitical factors: the Soviets had launched Sputnik into orbit, and the nervous West was ready to overhaul its scientific and technological education systems. A general algebraization of mathematics was implemented, first in the graduate schools that produced the math teachers, then in the schools where they taught. The Bourbaki ideology had taken hold in just a couple of decades, and by the

late 1960's math curriculum was all equations and numbers. There was not a visually inspiring diagram to be found.

For Coxeter and his intellectual disciples, the shift was sacrilege. A 1957 *Scientific American* article described the Bourbaki approach as “a style of presentation which is so bent on saying everything that it leaves nothing to the imagination and has, consequently, a watery, lukewarm effect.” Coxeter's weapons against this phenomenon were his textbooks. In 1961, he published *Introduction to Geometry*, an instant and enduring best-seller. It has since been translated into Japanese, Russian, Polish, Spanish, Hungarian and German. (“In the German translation, they gave it quite a nice title,” Coxeter says. “They called it *Unvergängliche Geometrie* — ‘unforgettable geometry, or everlasting geometry — because it never goes away.’”)

All of Coxeter's textbooks are classics, mathematical Dickens. Readers are drawn to them as much for their eloquence as for their whimsy and sense of wonder: they're generously adorned with quotations from the likes of Wordsworth, Shakespeare, Blake, Twain and H.G. Wells. In *Introduction to Geometry*, the chapter on two-dimensional crystallography is prefaced by a line from *Alice's Adventures in Wonderland*: “For some minutes Alice stood without speaking, looking out in all directions over the country. . . ‘I declare it's marked out just like a large chessboard. . . all over the world — if this is the world at all.’ ” In *Regular Complex Polytopes*, Coxeter quotes from Chesterton's *Manalive* (“All thought is reflection”) and includes several bars from the Fourth Symphony of Anton Bruckner, his favourite composer. Most important, the books are dense with hypnotically intricate graphics.

“Those books made geometry extremely popular again for the young generation,” says the Budapest conference organizer, Károly Bezdek, a balding math prof at Cornell and one of the leading researchers in computational discrete geometry. “I remember, as a child, when I first started to imagine three-dimensional things; there was a barricade when we encountered higher dimensions. Donald's books made it possible to learn that.” Just the other day, Bezdek says, he opened Coxeter's book on regular polytopes because his oldest son, having just seen *Star Wars*, expressed an interest in drawing multidimensional shapes.

“Coxeter kept a little flame of geometry alive by doing such beautiful works himself,” says John Conway, a mathematics professor at Princeton best known for having invented the computer game *Life*. “He has a certain way with presentation that is elegant and carries the reader along. With math, you're trying to prove something, and that can get

very complicated and ugly. He always manages to do it clearly and concisely, with beauty.”

Robert Moody, a math prof at the University of Alberta, agrees. In a letter nominating Coxeter for an honorary degree, he wrote: “Modern science is often driven by fads and fashions, and mathematics is no exception. Coxeter’s style is singularly unfashionable. He is guided almost completely by a profound sense of what is beautiful.”

This was Coxeter’s quiet strategy. He continued to work on classical geometry even when the field had become widely unpopular, and he did it for its elegance. “Nobody asks an artist why they do their art,” he says pointedly when asked about his pursuits. Indeed, Coxeter’s math is like a great piece of classical music: you go back to it again and again, just for pleasure. You may read one of his books the first time for its ideas but revisit it to marvel at its depth of meaning. About his *Regular Complex Polytopes*, Coxeter says: “I have made an attempt to construct it like a Bruckner symphony, with crescendos and climaxes, little foretastes of pleasure to come, and abundant cross-references. The geometric, algebraic and group-theoretic aspects of the subject are interwoven like different sections of an orchestra.”

Imre Toth, an excitable Hungarian mathematician who has retired to France, nicely sums up Coxeter’s passion played out in the history of geometry: “Coxeter remained with a high fidelity to geometry. He was the rock, the huge stone, which the Bourbakis were not able to destroy. He was the citadel against the Bourbakis. And he won.” Eventually, it is important to note, even the Bourbaki collective was convinced. Coxeter had a defender, as he liked to call him: Jacques Tits, a Belgian mathematician, who was also an “honourary” Bourbaki. He convinced the collective to consider Coxeter’s work particularly the areas in which he bridged the realms of classical and algebraic geometry. And sure enough, in the Bourbaki publication of 1968, on Lie Algebra, Coxeter’s work figured prominently. And in a nice twist of irony, it is within that Bourbaki treatise that the terms Coxeter Number, Coxeter Group and Coxeter Graph were first coined, entrenching his name in the geometric lexicon for all mathematical posterity.

Coxeter may have won that war, but he lost a few significant battles, including one at U of T, where he taught until his retirement in 1977. Over the past 30 or 40 years, the university has made no effort to hire new classical geometry professors. “It’s a bit of a disappointment,” says Coxeter. Today, the department has only one geometer doing classical-type work, and he’ll be gone in seven years when he hits 65, the mandatory retirement age.

York University, however, has three, and over the past couple of years Coxeter has relocated his archives there. (“I think the University of Toronto didn’t know what to do with my papers,” he says. “They were only too glad to have them off their hands.”) The Coxeter Library is maintained by Asia Weiss, one of his last Ph.D. students, now a professor at York.

Coxeter also revised his will. Several years ago, he had arranged to bequeath his \$1.5-million Rosedale house to the university when he died. He wanted it preserved as Coxeter House, a place where visiting mathematicians could stay and study. But as he watched U of T make no effort to sustain his field, his feelings changed.

He told the department that pure classical geometry should be allowed to flourish on its own, like the liberal arts, and urged his former colleagues, as well as the university, to maintain a balance between classical and applied mathematics. But to no avail. Coxeter decided to hold his house hostage in an attempt to make the university change its position. He wrote a letter that essentially said, “If you don’t foster education for education’s sake, you won’t get my house,” and instructed his daughter to hand-deliver it to the president’s nearby mansion. Susan talked her father out of sending the dramatic missive, which turned out to have been unnecessary: the university ultimately declined the bequest, saying the house would be too costly to maintain. It’s being used, for the moment, by the Fields Institute, Canada’s pre-eminent mathematical think-tank. The third floor, with the exception of Coxeter’s bedroom, has been converted into an apartment, currently home to a mathematician from Indiana.

Even people who know nothing about geometry have encountered Coxeter’s influence through the drawings of M.C. Escher. The two men met in 1954 at an international congress of mathematicians in Amsterdam. By then, Escher was growing tired of repeating birds and fish on a flat plane. He was aware of Coxeter’s work on the reflections of shapes in multidimensional space and wanted to know more. He later wrote to Coxeter, asking for suggestions on how to construct a series of objects that, as they approach a circle’s outer rim, become gradually smaller to the point of vanishing. Coxeter sent him some of his essays and diagrams on the topic.

Years later, he was amazed by what Escher, who claimed to be ignorant of mathematics, had created. He had made the angles of the etchings in his Circle Limit drawings mathematically perfect; the arabesques of intersecting arcs that form the backbones of the fish decrease in size infinitely outward, all at 80 degrees. Coxeter devoted

several papers to Escher's natural gift for geometry. "Escher did it by instinct," he explains. "I did it by trigonometry."

Walter Whiteley, who teaches discrete applied geometry at York University, says the applications of Coxeter's work go well beyond Escher and into the domain of medicine. "If you do a search on the Internet with symmetry and viruses," he says, "the images of viruses that come up look exactly like something of Coxeter's or Escher's. They are colour-coded proteins of a virus. You look at it and say, 'Gee, that's just a beautiful piece of geometry.' There's a very common one in the shape of the icosahedra which you often see in Donald's books. That's the common cold."

Coxeter's research also pops up in the unlikely world of e-commerce. "Geometry is used in designing algorithms, the mathematical essence of computer programs," explains László Lovász, a native of Hungary who is now mathematician-in-residence at One Microsoft Way in Redmond, Washington. Lovász's job nicely symbolizes the way geometry, a seemingly impractical art, intersects with applied math. Lovász doesn't do hands-on development work. Rather, he pursues his own areas of research, and Bill Gates pays him a retainer so he can be consulted when the programmers get stumped. In the field of computer algorithms, Lovász explains, the elementary classical interest in four mutually touching circles (the subject of Coxeter's talk in Budapest) is a hot topic. "It's central in the area of geometric representations of graphs," he says. "These geometric representations are related to issues in data-mining programming."

Data mining is about finding patterns in massive amounts of raw information. It's what amazon.com exploits when, after you buy or search for a book, the site prompts you with recommendations. For example, when you buy an edition of 12 essays by Coxeter under the title *The Beauty of Geometry*, the Web site announces: "Customers who bought this book also bought Coxeter's best-seller *Introduction to Geometry*, his *Fifty-Nine Icosahedra*, his *Regular Complex Polytopes*, and *Famous Problems of Geometry and How to Solve Them* by Benjamin Bold."

"Each customer is a data point," Lovász explains, "spending this much money here and that much money there, and so you get a set of points associated with each particular visit to the site. You get a huge number of points, because there are a huge number of customers. This generates points in some space that is higher-dimensional than three." Patterns are formed on graphs in multiple dimensions and become the monstrous shapes defined by Coxeter numbers and Coxeter groups —

in other words, computerized geometric representations of who buys what and when.

Coxeter — who has others send e-mails on his behalf and who has probably never even heard of amazon.com, let alone ordered anything from it — has no idea his work in the field of mutually tangent circles is an ancestor of so modern and commercial an invention. In fact, it befuddles him to hear about it, as if he were being told about a long-lost relative in whom he has little interest.

The same goes for his contributions to the field of astrochemistry, where he's also had a sizable impact. His work with icosahedral symmetries played a role in the 1996 Nobel Prize winning discovery of the carbon 60 molecule, now being tested as a superconductor for use in everything from chemotherapy to telecommunications to AIDS research. Previously, physicists were aware of only six forms of crystalline carbon — including graphite, as used in pencil lead, and diamond — but they speculated there was another. They had measured its vibrations, but they couldn't find it.

The structure of carbon 60 was finally discovered by two scientists from Rice University in Texas and one from the University of Sussex in the U.K. The structure they found was essentially that of the polyhedra Coxeter is so fond of working with. It looks roughly like a soccer ball, with 20 hexagonal surfaces and 12 pentagonal surfaces each a carbon atom. According to Robert Moody, "The only reason they found carbon 60 is that they knew what structure or arrangement of atoms they were looking for," he says, "based on Coxeter's equations."

A good nickname for the C60 molecule would have been the Coxeter ball. Instead, it was dubbed the Buckyball, for Buckminster Fuller, whose signature shape was itself inspired by Coxeter. Fuller was such a fan, he dedicated one of his books with this high praise: "Dr. Coxeter is the geometer of our bestirring 20th century, the spontaneously acclaimed terrestrial curator of the historical inventory of pattern analysis. I dedicate this work with particular esteem for him and in thanks to all the geometers of all time whose importance to humanity he epitomizes."

With any luck, Coxeter will continue to have many intellectual descendants. If not, says Whiteley, scientists will come up against puzzles and problems they lack the resources to solve. It would be like staging Macbeth with a script based on Coles Notes. Whiteley is particularly worried about North America's dependence on mathematicians imported from such places as Hungary. If geometry doesn't maintain a prominent place in our higher education system, he says, "the geometry gap will haunt the future of North America."

Coxeter's books will help prevent that. His *Introduction to Geometry*, for example, is on this year's undergraduate curriculum at McGill. Coxeter's famed revision of the 1887 text *Mathematical Recreations and Essays* is now in its 13th edition; and his personal favourite, *Regular Complex Polytopes*, published in 1974, went into its second edition in 1991.

Still, none of his books, however successful, fully captures the spirit of the man himself. Coxeter serves as an encyclopedia of sorts.

"You can take him a picture and ask, Have you ever seen anything like this before?" says Whiteley, "and he'll say yes and give you a geometrical metaphor or an exact reference. No computer is capable of answering those kinds of queries. How on earth are we going to replicate that when we don't have Coxeter?"

One evening in Budapest, Coxeter received a call in his hotel room from Gyorgy Darvas. A local geometer, Darvas was off to another mathematics gathering a couple of hours away. But he'd heard Coxeter would be in Budapest and did not want to miss the chance to speak with him. Coxeter slowly made his way downstairs to meet Darvas, who was waiting in the lobby.

"I've wanted to meet you for 50 years," Darvas said, and presented Coxeter with two copies of the Symmetry Society's journal, which he edits. He added that he would be happy to publish anything Coxeter sent his way. And he invited Coxeter to a conference, Symmetry Festival 2003, in Budapest the following year.

"Oh, how lovely," Coxeter said. He added with a guffaw, "But I won't be alive in 2003!"

Darvas gently pointed out that 2003 was only a year away.

"2-0-0-3," said Coxeter slowly, lost in thought. "Those numbers look so odd."

By the end of the conference, after a week of lectures and questions from fans, Coxeter was rejuvenated: he had reconsidered Darvas' invitation and was saying he'd be back in Budapest next year. One senses he would happily continue on with geometry, like Escher's Circle Limits, into infinity.