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There are many links between mathematics and the humanities, including literature and art. I'm excited to visit Kilachand and to explore some of these links with you. There's plenty more to discover, too. To whet your appetite, I've suggested below a few preparatory explorations you can look at if you wish, before we meet. I hope they will enrich your experience, but you'll still be able to follow everything even if you don't get the chance to delve into any these resources beforehand, so there's absolutely no pressure.

My Background

I'm a Professor of Mathematics at Birkbeck College (one of the colleges of the University of London), and concurrently Professor of Geometry at Gresham College, an institution founded in 1597 to provide free public lectures for all (happily nowadays only in English, after the requirement to lecture in both English and Latin was removed in the 18th century). My mathematics research is in an area of abstract algebra known as group theory, but alongside that I've always been fascinated by the place of mathematics as a creative art within culture and society more broadly. Here are some links if you want to find out more.

- The New York Times profiled me and my work in an article by Siobhan Roberts https://www.nytimes.com/2021/03/06/science/math-gresham-sarah-hart.html.
- I enjoyed being a guest last year Steven Levitt's podcast People I (Mostly) Admire. Steven is an economist best known for his smash hit book *Freakonomics*. You can listen at https://freakonomics.com/podcast/mathematician-sarah-hart-on-why-numbers-are-music-to-our-ears/ (or wherever you get your podcasts).
- As Gresham Professor of Geometry I give six free public lectures each year. They are all broadcast live, as well as recorded and posted on YouTube for anyone to watch free, forever. The most watched in the last year was "Where do Mathematical Symbols Come From?".

A Mathematical Journey through Literature

In this lecture we'll look at some of the many ways that mathematical ideas and structures can be found in literature. We'll hear about fractals in *Jurassic Park*, the beautiful algebraic principles governing various forms of poetry, and a novel whose underlying structure uses a mathematical puzzle that took 200 years to solve. The goal is to show you that not only are mathematics and literature inextricably linked, but that understanding these links can enhance your enjoyment of both.

All literature has structure. Words make sentences, sentences make paragraphs, paragraphs make chapters. Poems may have lines, stanzas, a meter, rhyme scheme. Mathematics is the natural language of structure, and that's the first way we see it in literature.

I'm going to give you a challenge now: write a thousand poems! The inspiration is the French writer Raymond Queneau, who published a book called *Cent mille milliards de poèmes* (One Hundred Thousand Billion Poems). It contained many possible choices for of each line of a sonnet, and the total number of possible sonnets it contained was therefore 100,000,000,000,000. You might like to think about how many versions of each line are needed to do this, how long it would take to read out every single sonnet, if you can read one per minute, and ask: is this therefore the longest book ever written?

As a warm-up, I'm going to challenge you now to write a thousand limericks. A limerick is a usually humorous poem of five lines, popularized by the Victorian writer Edward Lear, who published 212 limericks in his lifetime. In a limerick, lines 1, 2, and 5 rhyme with each other, as do lines 3 and 4, so the rhyme scheme is AABBA. To give you an idea of how you can write a thousand limericks, here is a sneak peek from my new book *Once Upon a Prime: The Wondrous Connections Between Mathematics and Literature*, which is out in the Spring – but you can pre-order it if you are keen!

Here are two not very good limericks (shown on the left and on the right, below) that I've invented to show you the method.

There once was a woman called Jane
Who constantly travelled by train
When going abroad
She couldn't afford
A wonderful journey by plane

There once was a person from Maine
Who never went out in the rain
Damp days left her bored
Oh how she adored
A week in the sunshine in Spain

From these two starting points, you can construct many more limericks. You do it by randomly picking lines from the two choices you have at each point. You can, for example, toss a coin to determine each line. If it's heads, you read the left-hand line; if tails, the line on the right. Brilliantly, there is a website justflipacoin.com that allows you to do this even without taking the trouble of finding a physical coin. I tried it just now and got Heads, Tails, Tails, Heads, Tails. So my new limerick reads:

There once was a woman called Jane
Who never went out in the rain
Damp days left her bored
She couldn't afford
A week in the sunshine in Spain

Since the poem has to "work" whichever option you pick for each line, if you want to try doing something like this, you need to understand the structure of the poem. As I noted already, the limerick has the rhyme structure AABBA. So, you need three "A" rhymes in each limerick. That means for two limericks you'll need six "A" rhymes. In this toy example, I chose Jane, train, Maine, rain, plane, Spain. If you wanted a third limerick you could try and weave in words like drain, pain, complain, and so on.

Our little poem set of two limericks has two choices for each of the five lines. There are two possible first lines. Each of these can be followed by two possible second lines. This means we have $2 \times 2 = 4$ possibilities for the first two lines. Each of these can in turn be followed by two options for Line 3, giving $2 \times 2 \times 2 = 8$ possibilities for the first three lines. At each stage, the number of possible poems doubles. With our five lines to choose, we end up with a total of $2 \times 2 \times 2 \times 2 \times 2$ = 32 bona fide limericks. But if we wrote just one more limerick, we'd have three choices for each line, meaning a total of $3 \times 3 \times 3 \times 3 \times 3 = 243$ limericks. Here's a third limerick, for your delectation.

There once was a girl from Bahrain
Who viewed snow and hail with disdain
The cold she abhorred
She cheered when she scored
A trip to the African plain

Congratulations, you are now the proud owner of thirty-one more limericks than are contained in the entire oeuvre of Edward Lear. If you can add a fourth limerick to this set, then the total number will leap to $4 \times 4 \times 4 \times 4 \times 4$, which is 1,024, and since I only wrote 243 of these, you are morally entitled to more than 75% of the worldwide fame that will surely result from the composition of over a thousand limericks.

It's an interesting philosophical question as to the extent to which we have really written 1,024 limericks, or Raymond Queneau a hundred trillion sonnets. With the introduction of randomness, what does authorship really mean?

Structure, then, is the first way that mathematics is present in literature. The second way is through the allusions and metaphors that writers use. At its simplest, think of how much the number three appears in fiction from fairy tales (three wishes, three bears) to Shakespeare (three witches). But writers like Hermann Melville, George Eliot, and Leo Tolstoy have all used much more sophisticated mathematical allusions (Jurassic Park, as we'll see in the talk, is somewhere inbetween). The third way that math appears is when it becomes part of the story – whether that's mathematician characters as in Chimamande Ngozi Adichie's *Half of a Yellow Sun*, or full-blown allegories of the fourth dimension like Edwin A. Abbott, *Flatland, A Romance of Many Dimensions.* Here's a list of twenty books with mathematical structures, allusions, themes, or characters. Why not pick one and read or re-read it? Incidentally, for a bit more detail on Melville's *Moby Dick* specifically, you can read my paper Ahab's Arithmetic: The mathematics of Moby Dick, my paper in the Journal of Humanistic Mathematics (which is open access, so it's free to read).

1. Edwin A. Abbott, *Flatland, A Romance of Many Dimensions* (1884).
2. Chimamanda Ngozi Adichie, *Half of a Yellow Sun* (Knopf, 2006).
3. Dan Brown, *The Da Vinci Code* (Doubleday, 2003).
4. Jorge Luis Borges, *Labyrinths* (Penguin Classics edition), (Penguin Books, 2000).
5. Italo Calvino, *Invisible Cities,* translated by William Weaver (Harcourt Brace Jovanovich, 1978).
6. Lewis Carroll, *Alice's Adventures in Wonderland* (1865).
7. Eleanor Catton, *The Luminaries* (Little, Brown and Company, 2013).
8. Michael Crichton, *Jurassic Park* (Arrow Books, 1991).
9. Mark Haddon, *The Curious Incident of the Dog in the Night-Time* (Doubleday, 2003).
10. James Joyce, *Dubliners* (1914); *Ulysses* (1922).
11. Yann Martel, *Life of Pi* (Mariner Books, 2002).
12. Hermann Melville, *Moby Dick* (1851).
13. Alice Munro, *Too Much Happiness* (Knopf, 2009) (the title story in this collection is about mathematican Sofia Kovalevskaya).
14. Yoko Ogawa, *The Housekeeper and the Professor* (Picador, 2009).
15. Alex Pavesi, *Eight detectives* (Henry Holt, 2020).
16. Georges Perec, *Life A User's Manual*, translated by David Bellos (Collins Harvill, 1987).
17. Tom Stoppard, *Arcadia: A Play in Two Acts* (Faber and Faber, 1993).
18. Jonathan Swift, *Gulliver's Travels* (1726).
19. Leo Tolstoy, *War and Peace* (1869).
20. Amor Towles, *A Gentleman in Moscow: A Novel* (Viking, 2016).