

Interview with Kit Yates

Dr Kit Yates is the author of *The Maths of Life and Death*, released on the 5th of September (in UK – Spring 2020 in US) - how mathematics plays a crucial role in helping us navigate the real world.

The book is available for pre-order on amazon: https://www.amazon.co.uk/Maths-Life-Death-Kit-Yates/dp/1787475425/ref=sr_1_1?crid=3IJZ4DBX9EH1E&keywords=the+maths+of+life+and+death&qid=1561580016&s=gateway&srefix=the+maths+of+%2Cstripbooks-intl-ship%2C231&sr=8-1

Maths is an unloved subject. It's a commonplace view that maths is hard, that maths is abstract and removed from everyday concerns. Why do you think that is?

There's no doubt that maths is perceived as polarising; despised by many and loved by just a few. As a mathematician interested in sharing the wonders of my subject, my biggest struggle is with this self-imposed false dichotomy: those who believe that they can do maths and those who think they can't. There are far too many of the latter. But there is almost no-one who understands no maths at all, no-one who cannot count. At the other extreme, for hundreds of years there have been no mathematicians who understand all of known mathematics. We all sit somewhere on this spectrum; how far we travel to the left or to the right depends on how much we think this knowledge can be useful to us. Exposing the uses and importance of maths in everyday life is one way to shift people along the spectrum, to bring them into the middle ground.

This is exactly what I've tried to do in my book. It's important to say upfront that *The Maths of Life and Death* is not a not a maths book. Nor is it a book for mathematicians. There isn't a single equation in it. The point of the book is not to bring back memories of the school mathematics lessons you might have given up years ago. Quite the opposite. If you've ever been disenfranchised and made to feel that you can't take part in mathematics or aren't good at it, consider this book an emancipation.

I genuinely believe that maths is for everyone and that we can all appreciate the beautiful mathematics at the heart of the complicated phenomena we experience daily. If you've ever been made to feel that you can't comprehend maths or aren't good at it, I say this: you are experiencing it all the time, perhaps without even knowing it. Mathematics, at its most fundamental, is pattern. If you spot a motif in the fractal branches of a tree, or in the multi-fold symmetry of a snowflake, then you are seeing maths. When you tap your foot in time to a piece of music, or when your voice reverberates and resonates as you sing in the shower, you are hearing maths. If you bend a shot into the back of the net or catch a cricket ball on its parabolic trajectory, then you are doing maths. Part of the job I undertake in the book is to highlight the places where people are using maths, intuitively, perhaps without even realising it.

Unfortunately, all too often, mathematics is viewed as a sterile, abstract subject: at best an esoteric plaything for out-of-touch academics, and at worst a waste of school children's time and taxpayers' money. Few explanations of everyday mathematics filter through to non-specialists.

Instead they are told that mathematics is inaccessible and inscrutable. Mathematics is often lauded for its beauty, its purity, its abstraction and otherworldliness; untainted by the messy details of reality. But for me, an applied mathematician, mathematics is first and foremost a practical tool to make sense of our complex world. Mathematical modelling can give us an advantage in everyday situations, and it doesn't have to comprise hundreds of tedious equations or lines of computer code to do so. In fact, the simplest models are stories and analogies. For me, the stories that comprise this book - the most basic models - are the most useful of all. When viewed through the right lens we can tease out the hidden mathematical rules that underlie our common experiences.

Is this attitude to maths changing?

I think societal changes are slowly altering attitude towards the importance of maths. As our economies change, there is growing awareness that we need more mathematicians, engineers and scientists to fill the increasing numbers of jobs in the technology sector. To some degree this is reflected in maths' rise to becoming the most popular A-level choice. This rise in popularity has also impacted on the number of students continuing to study mathematics in higher education. I always tell students who come to visit my department at open days, and who are trying to make up their mind about whether to study maths or not, that by studying maths they will only open doors for themselves and never close them. It's so easy to jump out of mathematics and into another discipline, but much harder to go back the other way.

For example, I myself am a *mathematical biologist*. When I tell people this, the reaction I get is usually a polite nodding of the head accompanied by an awkward silence, as if I was about to test them on their recall of the quadratic formula or Pythagoras' theorem. More than simply being daunted, people struggle to understand how a subject like maths, which they perceive as being abstract, pure and ethereal, can have anything to do with a subject like biology, which is typically thought of as being practical, messy and pragmatic.

I dropped biology at sixth-form and took A-levels in maths, further maths, physics and chemistry. When I went to university, I had to further streamline my subjects, and felt sad that I had to leave biology behind forever; a subject I thought had incredible power to change lives for the better. I was hugely excited about the opportunity to plunge myself into the world of mathematics, but I couldn't help worrying that I was taking on a subject that seemed to have very few practical applications. I couldn't have been more wrong.

Whilst I plodded through the pure maths we were taught at university I lived for the applied maths courses. I listened to lecturers as they demonstrated the maths that engineers use to build bridges so that they don't resonate and collapse in the wind, or to design wings that ensure planes don't fall out of the sky. I learned the quantum mechanics that physicists use to understand the strange goings-on at subatomic scales and the theory of special relativity that explores the strange consequences of the invariance of the speed of light. I took courses explaining the ways in which we use mathematics in chemistry, in finance and in economics. I read about how we use mathematics in sport to enhance the performance of our top athletes and how we use

mathematics in the movies to create computer-generated images of scenes that couldn't exist in reality. In short, I learned that mathematics can be used to describe almost everything.

I think as people start to see the way in which mathematics is increasingly pervading their everyday lives and to understand how even a little mathematical knowledge can be of benefit in real life, its importance will be increasingly realized. I also believe that when students see that there is a point to the maths they are being taught, rather than just rote learning to pass an exam, that maths can be transformed into something enjoyable.

This is what *the Maths of Life and Death* is all about. I try to convince the reader that maths is so much more than the esoteric subject they left behind at school. It is the false alarms that play on our minds and the false confidence that helps us sleep at night; the stories pushed at us on social media and the memes that spread through it. Maths is the loopholes in the law and the needle that closes them; the technology that saves lives and the mistakes that put them at risk; the outbreak of a deadly disease and the best way to control it. It is the best hope we have of answering the most fundamental questions about the enigmas of the cosmos and the mysteries of our own species. It leads us on the myriad paths of our lives and lies in wait, just beyond the veil, to stare back at us as we draw our final breaths.

A common everyday use of maths is in shopping - a trip to the greengrocer is one of the most cited examples in school maths teaching - but what are some other everyday, and more unusual uses of maths?

It's funny you should mention shopping, because there's actually so much more maths to shopping than just working out your change. For example, stores have traditionally over-represented price tags which end in .99, .95 or .90. In the UK .99 is the third most common price ending after .00 and .50. The marketing theory goes that because we read left to right we take account of the first digits on price tags, but ignore everything to the right of the decimal point. Unwittingly we are being tricked into thinking products are cheaper than they are because our brains are always subconsciously rounding down. In the book I also provide a nice rule of thumb called 'the 37% rule' which uses the maths of optimisation to help you join the shortest queue in the supermarket.

Of course there are so many more places where maths appears in everyday life. In the book, we explore the true stories of life-changing events in which the application (or misapplication) of mathematics has played a critical role: patients crippled by faulty genes and entrepreneurs bankrupt by faulty algorithms; innocent victims of miscarriages of justice and the unwitting victims of software glitches. I follow stories of investors who have lost fortunes and parents who have lost children, all because of mathematical misunderstanding. I wrestle with ethical dilemmas from screening to statistical subterfuge and examine pertinent societal issues such as political referenda, disease prevention, criminal justice and artificial intelligence. I show that mathematics has something profound or significant to say on all of these subjects, and more.

Rather than just pointing out the places in which maths might crop up, I also try to arm the reader with simple mathematical rules and tools which can help them in their everyday life: from getting

the best seat on the train, to keeping one's head when on the receiving end of an unexpected test result from the doctor. I suggest simple ways to avoid making numerical mistakes and get my hands dirty with newsprint when untangling the figures behind the headlines. I also get up close and personal with the maths behind consumer genetics and display maths in action as I highlight the steps we can all be taking to help halt the spread of deadly diseases.

How has your expertise in mathematical biology helped you with the book?

In the introduction I discuss the reasons I got into maths and specifically mathematical biology. My undergraduate lecturer and then PhD supervisor, Philip Maini, who is so well known in our community makes an appearance. The fact that the general public often find the idea of maths and biology working together in tandem so difficult to believe allows me to convince readers that maths really can have something to say in unexpected arenas. From a purely practical point of view being a mathematical biologist has enabled me to provide my readers with strong motivation.

Although the majority of the book is not focussed directly on our subject area, the last chapter, in which I explore the dynamics of disease spread, is inspired by mathematical epidemiology. The reason this makes such good subject matter for popularisation is that it is one of the areas in which mathematical biology is having the greatest impact on people's every day experiences. Despite the fact the epidemiology is not my main area of research, the contacts I've made through a variety of workshops, meetings and conferences (including the SMB annual conference) have been hugely helpful. Many of these contact (including the SMB's very own Newsletter editor Robin Thompson) have lent their time and expertise to discuss specific topics with me, or even to proof-read some of the material to make sure I haven't made any massive blunders.

More generally, my training as an applied mathematician has exposed me to many of the wide variety of practical and interesting areas in which mathematics is used in the real world. It has helped me know where to look for the good stories about how maths might influence the lives of real people.

What do you think are some of the benefits of a better understanding of maths?

A little mathematical knowledge in our increasingly quantitative society can help us to harness the power of numbers for ourselves. Simple rules allow us to make the best choices and avoid the worst mistakes. Small alterations in the way we think about our rapidly evolving environments help us to 'keep calm' in the face of rapidly accelerating change, or adapt to our increasingly automated realities. Basic models of our actions, reactions and interactions can prepare us for the future before it arrives. The stories relating other people's experiences are, in my view, the simplest and most powerful models of all. They allow us to learn from the mistakes of our predecessors so that, before we embark on any numerical expedition, we ensure we are all speaking the same language, have synchronised our watches, and checked we've got enough fuel in the tank.

Half the battle for mathematical empowerment is daring to question the perceived authority of those who wield the weapons – shattering the illusion of certainty. Appreciating absolute and

relative risks, ratio biases, mismatched framing and bias gives us the power to be sceptical of the statistics screamed from newspaper headlines, the 'studies' pushed at us in adverts or the half-truths that come tumbling from the mouths of our politicians. Recognising mathematical sleights of hand allows us to disperse obfuscating smoke screens, making it harder to fool us with mathematical arguments, be they in the courtroom, the classroom or the clinic.

We must ensure that the person with the most shocking statistics doesn't always win the argument, by demanding an explanation of the maths behind the figures. We shouldn't let medical charlatans delay us from receiving potentially life-saving treatment when benefits their alternative therapies are just a mathematical anomaly. We mustn't let anti-vaxxers make us doubt the efficacy of vaccinations, when mathematics demonstrates that they can save vulnerable lives and wipe out disease.

As I hope I show throughout the book, it is time for us to take the power back into our own hands, because sometimes maths really is a matter of life and death.