Annotated Bibliography

Cook, Mariana. *Mathematicians: An Outer View of the Inner World*. Princeton UP, 2009. Project MUSE, https://muse.jhu.edu/book/30228.

This coffee-table book contains portraits of ninety-two mathematicians, each accompanied by a short autobiographical essay. These essays illuminate the lives and research of mathematicians and help us understand why they do what they do. There is an abundance of quotable material in this volume, and the experience is only elevated by the crisp portraits of many prominent mathematicians whose names I recognised but whose faces I had never seen.

Du Sautoy, Marcus. *The Music of the Primes: Searching to Solve the Greatest Mystery in Mathematics*. Harper Perennial, 2011.

Although occasionally reductionistic in its presentation of the technical details, this book accomplishes its end as a compelling and readable history of the most famous open problem in mathematics: the Riemann Hypothesis. In addition to the development of Riemann's idea, Marcus du Sautoy extensively discusses the theory's implications in various fields outside of mathematics. Throughout, he describes what it is like to study mathematics, not for its applications, but for itself—for the beauty of the subject, and for its unique "immortality".

Gleick, James. *Chaos: Making a New Science*. Penguin, 2008.

This book explores how researchers from a remarkable variety of disciplines—physics, microbiology, economics, meteorology, cardiology, and ecology, just to name a few—converged on the same mathematical models. So-called "chaos theory" focuses on the dynamics of nonlinear systems and has profound implications for our understanding of complex phenomena of all kinds. With poetic flair, Gleick highlights the unifying role of mathematics in the sciences, emphasising throughout the elegance and beauty of its theories.

Hofstadter, Douglas R. *Gödel, Escher, Bach: An Eternal Golden Braid*. 20th anniv. ed., Basic, 1999.

While this book's central thesis—if such a thing can be said to exist in this case—is somewhat unrelated to mathematics *per se*, it nonetheless presents an abundance of mathematical ideas and connections with other disciplines. In conjunction with its masterful exposition of Gödel's incompleteness theorems, *GEB* tackles such diverse

topics as music, artificial intelligence (long before it was cool), and genetics—in each case drawing mathematical parallels that are really quite astonishing. Not only that, the entire book is, in a certain sense which would please the aesthetic sense of any mathematician, an elaborate extended metaphor for itself. For all these reasons and more yet, this book is my favourite of all time (at the time of writing). Although I knew that I enjoyed mathematics when I first started *GEB* in the seventh grade, this was one of my first encounters with the abstract mathematics I have come to love today, and most probably the progenitor of my fascination with interdisciplinarity.

Isaacson, Walter. *Einstein: His Life and Universe*. Simon and Schuster, 2008.

Einstein is of course best known as a physicist, but he jointly studied mathematics in university, and advanced mathematics were vital to his theory of general relativity. But more than his substantive contributions, I find his outlook on science most inspiring. Motivated by aesthetic considerations more than anything else, Einstein sought to unify our understanding of the universe using mathematics, and it is this pursuit of beauty and drive towards generalisation that, I believe, lie at the heart of the mathematical spirit.

———. *The Innovators: How a Group of Hackers, Geniuses and Geeks Created the Digital Revolution*. Simon and Schuster, 2014.

This history of computer development and culture demonstrates the close links between mathematics and computer science. Indeed, many pioneers of the digital revolution were mathematicians, whether by vocation or avocation. Even today, there is considerable migration and collaboration between the two fields.

Peters, Ole. "The Ergodicity Problem in Economics." *Nature Physics*, vol. 15, no. 12, 2019, pp. 1216–21, https://doi.org/10.1038/s41567-019-0732-0.

Not only do I find the subject matter of this paper extremely interesting, I think it provides an extremely clear example of the versatility of mathematics. The author, Ole Peters, is a physicist, writing in a physics journal, but this paper deals with a problem in *economics*. The remarkable thing is that the notion of statistical expectation in economics is fundamentally linked to our physical models for the behaviour of gas particles. Why? Because they use the exact same equations! Specifically, they rely on the assumption of ergodicity, which Peters goes to show is often a flawed assumption in the case of economics.

Schuller, Frederic P. “Topological Spaces: Construction and Purpose.” Lectures on the Geometric Anatomy of Theoretical Physics, no. 4, University of Erlangen-Nuremberg. *YouTube*, 21 Sep. 2015, www.youtube.com/watch?v=1wyOoLUjUeI.

I include this source for one particular comment I find interesting towards the end. In the middle of an otherwise extremely abstract lecture on topology, Schuller makes a short aside demonstrating how a particular theorem can be applied to the study of economics, of all things. No domain knowledge is required because the argument is purely mathematical, based on the very definition of what it means to *compare* things. No one watching this lecture would rightly expect such a connection to come up, yet this sort of thing is startlingly common in mathematics.

Simons, James H. Interview. Conducted by Brady Haran. *YouTube*, uploaded by Numberphile2, 13 May 2015, https://www.youtube.com/watch?v=QNznD9hMEh0.

This interview with former mathematics professor and billionaire hedge fund founder Jim Simons sheds light on his education, career, and philanthropy. He is very well-spoken and I find his insights quite edifying. The way he describes his mathematical interests in high school is also very similar to my own, which I find encouraging. Simons talks about the beauty and versatility of mathematics: how his purely mathematical research became, initially unbeknownst to him, central to various physics disciplines, including string theory; and how he used his knowledge of mathematics to found what is still, at the time of writing, the most successful investment vehicle of all time.

Singh, Simon. *The Simpsons and Their Mathematical Secrets*. Bloomsbury, 2014.

One option budding mathematicians may not consider is to become a writer for *The Simpsons*. No, I’m not joking. Many of the most famous writers for this iconic cartoon were highly educated mathematicians and physicists. (Although I would imagine that the time they spent at Harvard is not where they acquired their sense of humour.) With the innumerable mathematical references they’ve added over the years, *The Simpsons* has, in the words of one writer, engaged in a “decades-long conspiracy to secretly educate cartoon viewers”. Now, while I am not *personally* considering this as a career option, this is certainly a fun book that shows by example the unexpected places you can go with a mathematics degree.

Strogatz, Steven. *Infinite Powers: How Calculus Reveals the Secrets of the Universe*. Mariner, 2020.

This book is a very readable account of the development of calculus over the past two thousand years, replete with examples from unexpected places. Strogatz presents an excellent view of precisely *how* the language of mathematics is so effectively applied to our understanding of the natural world, and how its intuitions routinely guide us to new discoveries.

Tao, Terence. "What Is Good Mathematics?" *Bulletin of the American Mathematical Society*, vol. 44, no. 4, May 2007, pp. 623–34, https://doi.org/10.1090/S0273-0979-07-01168-8.

This article by the prominent mathematician Terence Tao discusses what it means to do "good mathematics". At times, the discussion gets a bit lost in the weeds, but it does provide a good exposition of what the mathematical research process looks like and what traits are desired by such researchers.

Thorp, Edward O. *A Man for All Markets: From Las Vegas to Wall Street, How I Beat the Dealer and the Market*. Random House, 2018.

This autobiography of Ed Thorp recounts his journey as a student, first in chemistry, then in physics, and finally to his doctorate in mathematics. In the 1960s, Thorp revolutionised gambling by inventing the method of "card counting" in blackjack, and by developing the world's first wearable computer to beat the game of roulette with physics. Thorp later went on to start the world's first quantitative hedge fund, applying mathematics to the financial markets. Throughout all of this, Thorp retained his position as a mathematics professor for over twenty years. Not only does this book showcase the versatility of mathematics, it demonstrates the principles of thinking that make someone successful in such a field: curiosity, creativity, and a certain scepticism of received knowledge.

"The Trillion Dollar Equation." Directed by Will Wood and Derek Muller. *YouTube*, uploaded by Veritasium, 27 Feb. 2024, https://www.youtube.com/watch?v=A5w-dEgIU1M.

This video explains the Black-Scholes-Merton option pricing model and the history of mathematical modelling in our financial markets. From the first attempts at option pricing made by physicist Louis Bachelier, to Einstein's modelling of particles in a dish resurfacing as the mechanics of random price movements, there is a long history of scientists succeeding in the field of finance. In the 1960s, the development of such equations gave rise to the Black-Scholes-Merton model and the resultant multi-trillion dollar industry of financial derivatives. (Incidentally, Ed Thorp came up with the model first, but he was too busy making millions of dollars to publish his results. Scholes and Merton won the Nobel Prize thirty years later.)

Voisin, Claire. “A Mathematician On Creativity, Art, Logic and Language.” Interview conducted by Jordana Cepelewicz. *Quanta Magazine*, 13 Mar. 2024, https://www.quantamagazine.org/a-mathematician-on-creativity-art-logic-and-language-20240313/.

In this interview, mathematician Claire Voisin talks about mathematics as a language with the challenges and rewards of its abstraction. It is interesting to see the connections between mathematics and art; this is a recurrent theme in the text. Voisin also describes her personal experience with mathematical research.

Wigner, Eugene P. “The Unreasonable Effectiveness of Mathematics in the Natural Sciences.” *Communications on Pure and Applied Mathematics*, vol. 13, no. 1, 1960, pp. 1–14, https://doi.org/10.1002/cpa.3160130102.

This classic paper discusses a fundamental question: Why is mathematics so useful in our understanding of the physical world? Surely there is no *a priori* reason for us to expect this. Wigner examines the role of mathematics in the sciences and makes distinctions between the use of mathematics as a source of truth and as a language to model the world. Especially interesting is the striking accuracy of mathematics in our extension of existing theories.