

## MATHS DEPARTMENT READING AND LISTENING LIST

### I Book list

#### Lower School

Hans Magnus Enzenberger & Michael Henry Heim, *The Number Devil: a Mathematical Adventure* (Granta, 2000)

Twelve-year-old Robert hates his maths teacher. He sets his class boring problems and won't let them use their calculators. Then in his dreams Robert meets the Number Devil who brings the subject magically to life, illustrating with wit and charm a world in which numbers can amaze and fascinate, where maths is nothing like the dreary, difficult process that so many of us dread. "The Number Devil" knows how to make maths devilishly simple.

Gerald Jenkins & Anne Wild, *Be a Codebreaker* (Tarquin, 1994)

A set of puzzles in ancient maps, mysterious deaths, lost cities and shipwrecks, which involve breaking codes using a letter frequency. There are principles to be followed but also opportunity for inspired guesses and good ideas.

#### Lower Fourth and above

Adam Case, *Who tells the Truth?* (Tarquin, 1990)

All the characters in these puzzles make clear statements about themselves and others, but it is not clear whether or not they are telling the truth. The problem is to decide which person to believe. Also, there are some curious paradoxical pictures which raise questions to answer.

E. R. Emmet, *A Diversity of Puzzles* (Barnes & Noble, 1978)

*No synopsis available*

#### Upper Fourth and above

David Acheson, *1089 and all that. A Journey into Mathematics* (OUP, 2002)

This excellent book, written by the established author and Oxford mathematician David Acheson, makes mathematics accessible to everyone. Providing an entertaining and witty overview of the subject, the text includes several fascinating puzzles, and is accompanied by numerous illustrations and sketches by world famous cartoonists. This unusual book is one of the most readable explanations of mathematics available.

Marcus de Sautoy, *The Music of the Primes. Why an unsolved problem in mathematics matters* (Harper Collins, 2004)

A critically-acclaimed popular science book by a writer who is fast becoming a celebrity mathematician. Prime numbers are the very atoms of arithmetic. They also

embody one of the most tantalising enigmas in the pursuit of human knowledge. How can one predict when the next prime number will occur? Is there a formula which could generate primes? These apparently simple questions have confounded mathematicians ever since the Ancient Greeks. In 1859, the brilliant German mathematician Bernard Riemann put forward an idea which finally seemed to reveal a magical harmony at work in the numerical landscape. The promise that these eternal, unchanging numbers would finally reveal their secret thrilled mathematicians around the world. Yet Riemann, a hypochondriac and a troubled perfectionist, never publicly provided a proof for his hypothesis and his housekeeper burnt all his personal papers on his death. Whoever cracks Riemann's hypothesis will go down in history, for it has implications far beyond mathematics. In business, it is the lynchpin for security and e-commerce. In science, it has critical ramifications in Quantum Mechanics, Chaos Theory, and the future of computing. Pioneers in each of these fields are racing to crack the code and a prize of \$1 million has been offered to the winner. As yet, it remains unsolved. In this breathtaking book, Oxford mathematician Marcus du Sautoy tells the story of the eccentric and brilliant men who have struggled to solve one of the biggest mysteries in science. It is a story of strange journeys, last-minute escapes from death and the unquenchable thirst for knowledge. Above all, it is a moving and awe-inspiring evocation of the mathematician's world and the beauties and mysteries it contains.

Simon Singh, *Fermat's Last Theorem: the story of a riddle that confounded the world's greatest minds for 358 years* (Fourth Estate, 1997)

When Cambridge mathematician Andrew Wiles announced a solution for Fermat's last theorem in 1993, it electrified the world of mathematics. After a flaw was discovered in the proof, Wiles had to work for another year – he had already laboured in solitude for seven years – to establish that he had solved the 350-year-old problem, and was helped by Old Waynflete Richard Taylor. Simon Singh's book is a lively, comprehensible explanation of Wiles's work and of the colourful history that has build up around Fermat's last theorem over the years. The book contains some problems that offer a taste for the maths, but it also includes limericks to give a feeling for the quirkier side of mathematicians

John Derbyshire, *Prime Obsession: Bernard Riemann and the greatest unsolved problem in mathematics* (2003)

Bernhard Riemann was an underdog of sorts, a malnourished son of a parson who grew up to be the author of one of mathematics' greatest problems. In *Prime Obsession*, John Derbyshire deals brilliantly with both Riemann's life and that problem: proof of the conjecture, "All non-trivial zeros of the zeta function have real part one-half." Though the statement itself passes as nonsense to anyone but a mathematician, Derbyshire walks readers through the decades of reasoning that led to the Riemann Hypothesis in such a way as to clear it up perfectly. Riemann himself never proved the statement, and it remains unsolved to this day. *Prime Obsession* offers alternating chapters of step-by-step math and a history of 19th-century European intellectual life, letting readers take a breather between chunks of well-written information. Derbyshire's style is accessible but not dumbed-down, thorough but not heavy-handed. This is among the best popular treatments of an obscure mathematical idea, inviting readers to explore the theory without insisting on page

after page of formulae. In 2000, the Clay Mathematics Institute offered a one-million-dollar prize to anyone who could prove the Riemann Hypothesis, but luminaries like David Hilbert, G.H. Hardy, Alan Turing, André Weil, and Freeman Dyson have all tried before. Will the Riemann Hypothesis ever be proved? “One day we shall know”, writes Derbyshire, and he makes the effort seem very worthwhile

Denis Guedj, *Numbers: the Universal Language* (Thames & Hudson, 1998)

This book describes, in words and with artworks, the basic principles of numbers: arithmetic, whole numbers, natural numbers and the concepts of zero and infinity. It examines how old numbers are and how they were developed; who invented algebra, geometry and calculus; how these ideas affect our daily lives; and the ways in which numbers have been used in art, music and other disciplines.

David Blatner, *The Joy of Pi* (Penguin, 1998)

For 4000 years we have struggled with pi – the ratio of a circle's circumference to its diameter. This book tells the story of pi, from Archimedes to da Vinci, and from Newton to the Chudnovsky brothers, who are calculating pi to billions of places with a homemade supercomputer.

David Boyle, *Tyranny of Numbers* (Harper Collins, 2001)

Too often we try to quantify what can't actually be measured. We count people, but not individuals. We count exam results rather than intelligence, benefit claimants instead of poverty. The government has set itself 10,000 new targets. Politicians pack their speeches with skewed statistics: crime rates are either rising or falling depending on who is doing the counting. We are in a world in which everything is designed only to be measured. If it can't be measured it can be ignored. The problem is what numbers don't tell you - they won't interpret, they won't inspire, and they won't tell you precisely what causes what. In this book, David Boyle examines our obsession with numbers. He reminds us of the danger of taking numbers so seriously at the expense of what is non-measurable, non-calculable: intuition, creativity, imagination, and happiness.

Theoni Pappas, *Mathematical Scandals* (World Wide Publishing, 1997)

Mathematics can be a passionate subject, and this text introduces the human sides and foibles of mathematics and mathematicians. Each scandal is introduced by a vignette which, although fictional, follows factual historical accounts.

## II Radio programmes

**‘In Our Time’ BBC Radio 4 programmes (all 42 minutes)**

[http://www.bbc.co.uk/radio4/history/inourtime/inourtime\\_science.shtml](http://www.bbc.co.uk/radio4/history/inourtime/inourtime_science.shtml)

## THE MEASUREMENT PROBLEM IN PHYSICS

The most famous fruit in physics is an apple, but the most famous animal in physics is a cat. It belongs to Edwin Schrödinger, a theoretical physicist who in the early 20<sup>th</sup>

century helped to develop the radical theories of Quantum Mechanics. Schrödinger's cat does not actually exist – it is the subject of a thought experiment – in which the rules of quantum mechanics make it appear both dead and alive at the same time.

The problem of a cat that is both dead and alive illustrates the challenges of quantum physics and at the heart of this apparent absurdity is a thing called the measurement problem. The measurement problem arises because we don't really understand how the atoms that constitute our world behave. They are fundamentally mysterious to us, even shocking, and they defy our attempts to measure and make sense of them. Possible solutions range from the existence of multiple realities to the rather more mundane possibility of an error in our mathematics - but a solution, if found, could transform our understanding of reality.

**Basil Hiley**, Emeritus Professor of Physics at Birkbeck, University of London

**Simon Saunders**, Reader in Philosophy of Physics and University Lecturer in Philosophy of Science at the University of Oxford

**Roger Penrose**, Emeritus Rouse Ball Professor of Mathematics at the University of Oxford

## **GÖDEL'S INCOMPLETENESS THEOREMS**

In 1900, in Paris, the International Congress of Mathematicians gathered in a mood of hope and fear. The edifice of maths was grand and ornate but its foundations, called axioms, were shaking with inconsistency and lurking paradox. And so, at that conference, a young man called David Hilbert set out a plan to rebuild them – to make them consistent, all encompassing and without any hint of a paradox.

Hilbert was one of the greatest mathematicians that ever lived, but his plan failed, spectacularly, and it did so because of the incompleteness theorems. These were the work of Kurt Gödel and they changed the way we understand maths, took us to the very limits of logic and sent challenges spilling out into the worlds of physics, philosophy and beyond.

**Marcus du Sautoy**, Professor of Mathematics at Wadham College, University of Oxford

**John Barrow**, Professor of Mathematical Sciences at the University of Cambridge and Gresham Professor of Geometry

**Philip Welch**, Professor of Mathematical Logic at the University of Bristol

## **PROBABILITY**

Heads or tails? It's a simple question with a far from simple answer. One that takes us into the strange and complex world of probability. Probability is the field of maths relating to random events and, although commonplace now, the idea that you can pluck a piece of maths from the tumbling of dice, the shuffling of cards or the odds in the local lottery is a relatively recent and powerful one. It may start with the toss of a coin but probability reaches into every area of the modern world, from the analysis of society to the decay of an atom.

**Marcus du Sautoy**, Professor of Mathematics at the University of Oxford

**Colva Roney-Dougal**, Lecturer in Pure Mathematics at the University of St Andrews  
**Ian Stewart**, Professor of Mathematics at the University of Warwick

## **THE FIBONACCI SEQUENCE**

1, 1, 2, 3, 5, 8, 13, 21, 34 ... this is the beginning of the Fibonacci sequence, an infinite string of numbers named after, but not invented by, the 13<sup>th</sup> century Italian mathematician Fibonacci. It may seem like a piece of mathematical arcania, but the Fibonacci sequence is found to appear, time and time again, among the structures of the natural world and even in the products of human culture. From the Parthenon to pine cones, from the petals on a sunflower to the paintings of Leonardo da Vinci, the Fibonacci sequence seems to be written into the world around us.

**Marcus du Sautoy**, Professor of Mathematics at the University of Oxford

**Jackie Stedall**, Junior Research Fellow in History of Mathematics at Queen's College, Oxford

**Ron Knott**, Visiting Fellow in the Department of Mathematics at the University of Surrey

## **SYMMETRY**

Today we will be discussing symmetry, from the most perfect forms in nature, like the snowflake and the butterfly, to our perceptions of beauty in the human face. There's symmetry too in most of the laws that govern our physical world. The Greek philosopher Aristotle described symmetry as one of the greatest forms of beauty to be found in the mathematical sciences, while the French poet Paul Valery went further, declaring; "The universe is built on a plan, the profound symmetry of which is somehow present in the inner structure of our intellect".

The story of symmetry tracks an extraordinary shift from its role as an aesthetic model - found in the tiles in the Alhambra and Bach's compositions - to becoming a key tool to understanding how the physical world works. It provides a major breakthrough in mathematics with the development of group theory in the 19<sup>th</sup> century. And it is the unexpected breakdown of symmetry at sub-atomic level that is so tantalising for contemporary quantum physicists. So why is symmetry so prevalent and appealing in both art and nature? How does symmetry enable us to grapple with monstrous numbers? And how might symmetry contribute to the elusive Theory of Everything?

**Fay Dowker**, Reader in Theoretical Physics at Imperial College, London

**Marcus du Sautoy**, Professor of Mathematics at the University of Oxford

**Ian Stewart**, Professor of Mathematics at the University of Warwick

## **THE POINCARÉ CONJECTURE**

The great French mathematician Henri Poincaré declared: "The scientist does not study mathematics because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing and life would not be worth living. And it is because simplicity, because grandeur, is beautiful that we preferably seek simple facts, sublime facts, and that we delight now to follow the majestic course of the stars."

Poincaré's ground-breaking work in the 19<sup>th</sup> and early 20<sup>th</sup> century has indeed led us to the stars and the consideration of the shape of the universe itself. He is known as the father of topology – the study of the properties of shapes and how they can be deformed. His famous Conjecture in this field has been causing mathematicians sleepless nights ever since. He is also credited as the Father of Chaos Theory. So how did this great polymath change the way we understand the world and indeed the universe? Why did his conjecture remain unproved for almost a century? And has it finally been cracked?

**June Barrow-Green**, Lecturer in the History of Mathematics at the Open University  
**Ian Stewart**, Professor of Mathematics at the University of Warwick  
**Marcus du Sautoy**, Professor of Mathematics at the University of Oxford

## **PRIME NUMBERS**

2, 3, 5, 7, 11, 13, 17... I could continue but we may be here for some time. The sequence of numbers which we will be speaking about today quite literally goes on forever. Last month a team of researchers in Missouri successfully calculated the highest prime number - it has 9.1 million digits. For nearly two and a half thousand years, since Euclid first described the prime numbers in his book Elements, mathematicians have struggled to write a rule to predict what comes next in the sequence. The Swiss mathematician Leonhard Euler feared that it is "a mystery into which the human mind will never penetrate." But others have been more hopeful ...

In the middle of the nineteenth century, the German mathematician Bernhard Riemann discovered a connection between prime numbers and a complex mathematical function called the 'zeta function'. Ever since, mathematicians have laboured to prove the existence of this connection and reveal the rules behind the elusive sequence. What exactly are prime numbers and what secrets might they unlock about our understanding of atoms? What are the rules that may govern the prime sequence? And is it possible that the person who proves Riemann's Hypothesis may bring about the collapse of the world financial system?

**Marcus du Sautoy**, Professor of Mathematics and Fellow of Wadham College at the University of Oxford

**Robin Wilson**, Professor of Pure Mathematics at the Open University and Gresham Professor of Geometry

**Jackie Stedall**, Junior Research Fellow in the History of Mathematics at Queen's College, Oxford

## **PI**

In the Bible's description of Solomon's temple it comes out as three, Archimedes calculated it to the equivalent of 14 decimal places and today's super computers have defined it with an extraordinary degree of accuracy to its first 1.4 trillion digits. It is the longest number in nature and we only need its first 32 figures to calculate the size of the known universe within the accuracy of one proton.

We are talking about Pi, 3.14159 etc, the number which describes the ratio of a circle's diameter to its circumference. How has something so commonplace in nature

been such a challenge for maths? And what does the oddly ubiquitous nature of Pi tell us about the hidden complexities of our world?

**Robert Kaplan**, co-founder of the Maths Circle at Harvard University and co-author of *The Art of the Infinite* (Allen Lane, 2003)

**Eleanor Robson**, Lecturer in the Department of History and Philosophy of Science at Cambridge University

**Ian Stewart**, Professor of Mathematics at the University of Warwick

### **III iTunes U podcasts**

**Oxford University iTunes U (<http://itunes.ox.ac.uk/>)**

Marcus du Sautoy on Pi Day (13 mins)