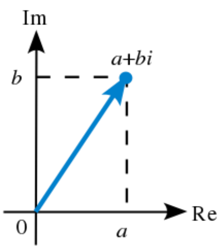
Past Birmingham Popular Maths Lectures (2017/2018)

20/09/2017
London Mathematical Society Popular Lectures

The unreasonable effectiveness of physics in mathematics
Professor David Tong
and
Adventures in the 7th dimension
Dr Jason Lotay

18/10/2017
Did Galois deserve to be shot?
Dr Peter Neuman *(Queen's College, Oxford)*

Classical algebra may be said to deal with equations. Modern algebra deals with abstract theories. Two of those are called group theory and Galois theory. We owe the transition from classical to modern mainly to Évariste Galois, who died aged 20 in 1832, shot in a mysterious early-morning duel. His ideas, after they were published fourteen years later, changed the direction of algebra and have had a huge influence on mathematics. In this session I propose to sketch his short and turbulent life, and explain to a non-expert audience something of his mathematical insights, and why he invented groups and what is now his eponymous theory.



29/11/2017
Numbers
Professor Paul Flavell (*University of Birmingham*)

Gauss is widely regarded as the greatest mathematician who ever lived. In his doctoral thesis, he proved the Fundamental Theorem of Algebra namely:

The output of any non-constant polynomial function can be any number.

We will prove this result. The first step in doing so will be to understand the vocabulary – in particular, what a number is. We'll focus on the idea of a number being used to measure things, so we'll start with whole numbers, which can be used to measure how much money we have. Moving on, we introduce fractions and numbers like the square root of two to get the real numbers. These can be used to represent distances, temperature, DC voltages and so on.

In order to prove the Fundamental Theorem of Algebra, we need to go further and introduce Complex Numbers. What do these measure?

The lecture will conclude with a geometric proof of the Fundamental Theorem.

31/01/2018
Saving the bees – why do we need maths?
Dr Martine Barons (*University of Warwick*)

"Professor Einstein, the learned scientist, once calculated that if all bees disappeared off the earth, four years later all humans would also have disappeared." Abeilles et fleurs, June, 1965.

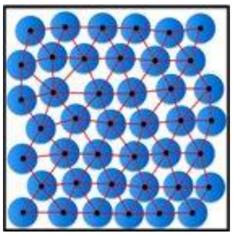
In recent years there has been much concern about declining insect pollinator populations leading to the UK's national pollinator strategy and a temporary Europe-wide ban on the use of Neonicotinoid insecticides. The insect pollinator system is typical of today's ever more interconnected world, and is one of the complex contemporary policy problems that expert evidence from different areas of expertise which interlock and interact, a way of dealing with uncertainty, as well as for managing complex questions at different scales.

How can we use maths to overcome this problem? I will outline the answers to these questions through the example of food security and pollination.

28/02/2018
How maths has been used and is being used in video games
Dr Richard Lissaman (*University of Warwick*)

In this talk we'll look at interesting applications of school/college level mathematics in video games. This will include looking at how coordinate geometry, vector and matrix techniques are used for graphics and collision detection as well as how mathematical algorithms have been used more generally. For example, did you know that the scalar product can be used to detect collisions and to produce convincing lighting in three dimensions? You'll see how a sequence like the Fibonacci sequence was used to pack a 2,000 planet galaxy into 16K of memory. The tour will take in gaming classics like Breakout, Asteroids, Pac Man, Elite and Tomb Raider.

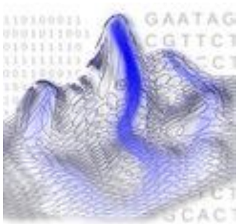
Past Birmingham Popular Maths Lectures (2016/2017)



19/10/16
Packing disks and spheres: the mathematics of water and ice
Dr Will Perkins - School of Mathematics - University of Birmingham

Why do liquids freeze to solids?

While this is one of the most basic of scientific questions, there is still much that we don’t understand. I will describe one approach to answering this question involving the cooperation of experimental physicists, theoretical phsyicists, computer scientists and pure mathematicians.   Our story begins in pre-revolutionary France, then moves to atomic research in Los Alamos, to modern Big Data algorithms, and finally to cutting-edge research in physics and mathematics.



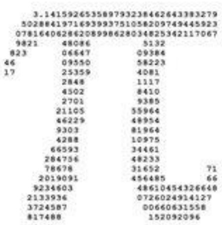
16/11/16
Simulating evolution solves problems throughout the sciences
Dr Iain Johnston - School of Biosciences - University of Birmingham

Evolution is an amazing problem solver, coming up with intricate and powerful solutions to natural challenges. With the help of computer simulations, science has started to learn from evolution -- representing real-world problems from fields like engineering and medicine as mathematical "ecosystems", and using artificial evolution to find solutions to these problems. I'll talk about the power of evolution as a problem solver, how maths can describe and model evolution, and how technological advances -- from satellite aerials to efficient crop plants -- have arisen from this meeting of maths and biology.

7/12/2016
Mathematics: The Queen of Science
Dr Nira Chamberlain CMA TH FIMA CSci

In Scientific and Engineering Great Discoveries, mathematics seems to play a supporting role to these important disciplines. However, there is one field in which mathematics is the Queen of Science; Mathematical Modelling. Mathematical modelling has always played a leading role in human achievements. From the discovery of Blacks Holes and the Planet Neptune to driving BloodHound Land-speed record attempt of next year.

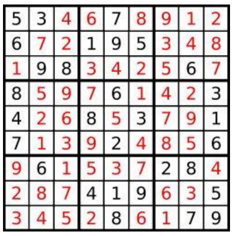
Nevertheless, is there a Star-Wars 'dark side' of mathematical modelling? Was mathematical modelling responsible for the World Economical Crash of 2008? Will mathematical modelling create automated robots that will surpass human intelligence and enslave us?



18/01/2017
The Story of π
Professor Robin Wilson

This talk covered the entire history of π, from the ancient Egyptians and Mesopotamians, via Archimedes, China and the Middle Ages, to the Indiana court case and the advances of the modern computer age.

Robin Wilson is an Emeritus Professor of Pure Mathematics at the Open University and Emeritus Professor of Geometry at Gresham College, London. He has written and edited many books on the history of mathematics, including Lewis Carroll in Numberland, and also on graph theory, including Introduction to Graph Theory and Four Colours Suffice. He has Erdős Number 1



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9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

15/03/2017
Sudoku - a special Latin square
Dr Allan Lo

A Sudoku is a mathematical puzzle appearing in many newspapers. The objective is to fill a 9×9 grid with numbers 1,2,..,9 such that each column, each row, and each of the nine 3×3 subgrids contains every number precisely once. While completing these puzzles is fun and challenging, there are many related mathematical results and applications. For instance, a completed Sudoku is an example of a Latin square, which has already been studied back in the 1770s. I will talk about the history of Latin squares as well as their influences in the modern society.

15/03/2017
Origami and Mathematics
Dr Jonathan Meddaugh

Origami allows for an incredible variety of objects to be constructed from a simple sheet of paper. Traditional origami creations include relatively simple shapes including the familiar origami crane. Modern origami artists have pushed the limits of the medium and through the clever use of geometry have been able to create some truly amazing art. The art of origami is of course significantly informed by the mathematics, but perhaps more surprisingly, mathematics can be informed by origami. We will discuss applications of origami in geometric constructions and the design of airbags and telescope lenses.

Past Birmingham Popular Maths Lectures (2015/2016)

23/9/15
London Mathematical Society Popular Lectures

The Mathematics of Randomness
Professor Martin Hairer, FRS Regius Professor of Mathematics, University of Warwick
and
A good new millennium for prime numbers
Professor Ben Green, FRS, Waynflete Professor of Mathematics, University of Oxford

21/10/15
The children of Erdős
Dr Andrew Treglown (University of Birmingham)

Paul Erdős was perhaps the most remarkable mathematician of the 20th Century. A vagabond, he would travel from country to country, appearing outside mathematicians' homes declaring "My mind is open!".

Through his nomadic lifestyle he worked with more than 500 mathematicians and unbelievably wrote more than 1500 research papers. His work has had profound implications to a wide variety of areas such as Analysis, Combinatorics, Number theory, Probability theory and Set theory. In this talk I will describe the personality and the mathematical legacy of "Uncle Paul". I will also describe how his work has influenced research undertaken in Birmingham today.

18/11/15
Transforms: Dark of Matter
Dr Alessandro Mottura (University of Birmingham)

Materials science is a discipline that links the properties of all materials to their inner structure at various length-scales. Thanks to this, we have made several advances in technology that today allow us to have 800m-tallskyscrapers, 640tons-heavy planes, and a whole lot of computationalpower in our pockets.

To break through the next frontiers of technology, however, we need to be able to explore the inner structure ofmaterials with details at a level neverimaginable before! The times when wecould use a simple optical microscopeare long gone, and materials scientists around the world now use far more advanced techniques to probe deeper and in more details inside the wonderful world of materials.

9/12/15
Mighty Morphogenesis, or how the fish got is spots
Dr Thomas Woolley (University of Oxford)

During his short life Alan Turing revolutionised the fields of logic, computation, mathematics and cryptoanalysis, doing all of this before he was even 42. Here, I will present a celebration of his work and focus on one of his least well-known theories about the construction of patterns and its applications to biological complexity. This work was so far ahead of its time that it took another 30-40 years before it was fully appreciated and, even today, it is still able to provide new avenues of research.

Starting from an intuitive understanding of his theory I will lead you through 60 years of beauty in terms of mathematics and patterns. Critically, by the end of the talk you should understand why mathematicians love cheetahs, but hate ring tailed lemurs.

20/1/1
Big Data
Dr Richard Pinch

The total amount of information generated by the human race before the digital age was around one Exabyte (one million million million letters). Today, that amount of data is circulated across the internet in a matter of days.

Information networks are generating data of a kind and scale not seen before. How much information is there in that data, how can it be extracted and managed, and what use can we make of it? This talk shows how mathematics helps to provide some of the answers.

23/3/1
Explosive Bubbles
Dr David Leppinen (University of Birmingham)

Anyone who has shaken a bottle of fizzy drink and then removed the lid knows that bubbles are explosive. There are many practical applications where bubble dynamics play an important role. This talk will consider three separate cases. First we will investigate cavitation which has a wide range of military, industrial and biomedical applications. Next we will examine dissolved air flotation which is a widely used process for drinking water purification. Finally we will consider the role of bubble formation in the modelling of decompression sickness. Bubbles are fascinating.

Past Birmingham Popular Maths Lectures (2014/2015)

24/9/14   The London Mathematical Society Popular Lectures

What's in a number?
Professor Kevin Buzzard (Imperial College London)
and
Epidemics and Viruses: the mathematics of disease
Dr Julia Gog (University of Cambridge)

22/10/14
Astrostatistics: Counting extra-solar Earths, hearing the mergers of galaxies, and seeing black holes.
Dr Will Farr (University of Birmingham)

Astronomy is entering a new era. Unlike the photographic plates of previous generations, modern astronomical data sets can comprise terabytes of databases describing the state of the telescope, properties of objects identified in the images, links to previous observations of the same field, and---of course---the actual images taken by the telescope. The vast amount of data and the special challenges of astronomical observations have given rise to a new field, astrostatistics, which is devoted to analysing these data sets and drawing conclusions about the astronomical objects in them. Through examples, including counting the number of Earth-like exoplanets in the universe, listening to the hum from merging super-massive black holes at the centres of galaxies over cosmic time, and observing gravitational waves from coalescing solar-mass black holes, I will illustrate some of the new techniques from this marriage of modern statistics---particularly computational statistics---with astronomy.

19/11/14
How to make the biggest Airbus fly
Professor Michal Kocvara (University of Birmingham)

The aircraft industry is very conservative, for obvious reasons. Usually when a manufacturer decides to design a bigger aircraft, the engineers just start with the existing design of a smaller aircraft of the same type and scale it up. However when Airbus decided to build the biggest ever passenger aircraft, the A380, this approach did not work. Using a scaled up existing design resulted in wings that were too long to fit in commercial airports. Even when redesigned and shortened, the wings were two times heavier than that which would allow the aircraft to fly. So the company decided for the first time to use "unconventional" tools of structural optimization to design their aircraft.

Structural optimization is a subject on the border between mechanical engineering and mathematics. Dealing with mechanical structures such as bridges or aircraft wings, it relies on foundations of elasticity theory. But in the search for better structures, it employs theory and tools of mathematical optimization. I will present a particular model of so-called free material optimization, in which we seek an "ultimate material", its distribution and properties. After introducing the basic mathematical formulation of the optimization problem, I will show how tools of modern mathematical optimization enable us to reformulate this model into another one, computationally much more approachable. To illustrate the practical usefulness of this technique, I will show how it was used for optimization of the leading edge of the wing in Airbus A380.

3/12/14
The Mathematics of Voting
Dr Chris Good (University of Birmingham)

We tend to feel fairly smug, living in democracies, about our system of government, but are elections fair? Do they really reflect the views of the electorate? Certainly many people are unhappy with the 'First-Past-the-Post' electoral system used in the UK, espousing instead some form (or other) of proportional representation. Would such a system be better? How can we make a judgment?

In fact, when we analyze voting mathematically, it becomes clear that all system of aggregating preferences(electing a parliament or a president, agreeing on who should win Pop Idol or Strictly Come Dancing, deciding the winner of the Premiership or the Formula 1 Championship) can throw up anomalies, unfairnesses and down-right weirdness.

How weird can things get? Well, in 1972, Kenneth Arrow (Harvard, USA) and John R. Hicks (Oxford, UK) were jointly awarded the Nobel Prize for Economics 'for their pioneering contributions to general economic equilibrium theory and welfare theory.' At the heart of Arrow's contribution to economic theory is his so-called 'Impossibility Theorem,' which (roughly speaking) says that there is no fair voting system. More precisely, once we agree what a fair voting system is, one can show that the only fair voting system is one in which there is a dictator who decides what every outcome will be. But there clearly cannot be a dictator in any fair voting system, so a fair voting system is impossible.

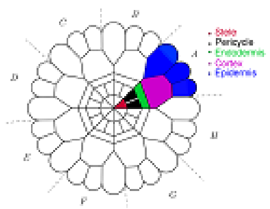
In this talk, we shall compare some voting methods and then discuss Arrow's Impossibility Theorem. Hopefully the talk will engender surprise, contention and disbelief.

21/1/15
Fighting disease with mathematics
Dr Sara Jabbari (University of Birmingham)

How can mathematics be used to understand antibiotic resistance, track the dynamics of viral infections or even develop new drugs to tackle disease?

As our knowledge of diseases becomes increasingly detailed and complex, more tools are required to interpret and use this information. Mathematical modelling is one such tool. Differential equations can be employed to simulate and understand disease mechanisms, venturing into places that experimental work cannot go, be that for practical, financial or even moral reasons.

We will explore a range of examples illustrating how maths can be used to understand disease, improve existing treatments and create entirely new ones.



18/3/15
Mathematical Lego: building a model plant
Dr Rosemary Dyson (University of Birmingham)

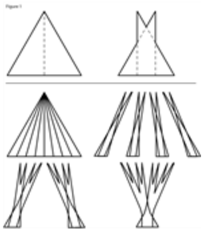
It may not always seem like it, but plants can undergo incredible shape changes and movement, from leaves following the sun through the course of a day, to the Venus flytrap catching its prey, to trees growing over 100m tall. If we want to understand, and hence control, these shape changes (for example to make a crop grow better under drought or flood conditions) we need to understand how a single cell can manipulate the mechanical properties of its cell wall, what those properties tell us how an individual cell grows, and what that in turn tells us about how lots of cells tightly stuck together (i.e. the whole plant) behave. This is where mathematical modelling comes in!

Using equations which describe how the bits of the cell wall interact as the building blocks of our mathematical models, we can use maths to work out what the overall behaviour will be. It is a bit like using small individual Lego bricks to build a much larger physical model. This lets us see what effect making changes to individual cells has on the shape of the whole plant. In turn, this allows us to find out lots of interesting things about how plants work, but much more quickly and cheaply than with traditional biological experiments! This work has transformed the way we study plant growth, and now forms the basis of research undertaken around the world.

RESCHEDULED to 22/4/15
The real science behind Parallel Universes
Dr Tony Padilla (University of Nottingham)

Have you always wanted to be a rock star? In a parallel reality your wish came true. Is this the real life, or is this just fantasy? Learn about the real science behind parallel universes as I take us on a journey of discovery through the multiverse to different parallel worlds, from those that exist all around us to those that are unimaginably far away. Travel across the landscape of string theory to watch new universes bubbling into existence, and visit island universes that are marooned in a sea of extra dimensions. Understand how you can create new universes closer to home just by tossing a coin, and find out why you might be nothing more than a Boltzmann brain, floating through empty space with false memories.

Past Birmingham Popular Maths Lectures (2013/2014)



11/9/13
The Kakeya Needle Problem
Professor Jon Bennett (University of Birmingham)

In 1917 the Japanese Mathematician Soichi Kakeya raised a very simple question: what is the minimum area required to turn a line of length 1 through 180 degrees in the plane? In this lecture we discuss the very surprising answer to this question, and indicate how such problems have come to lie at the heart of modern mathematics.

9/10/13
The Maths Juggler
Dr Colin Wright

Juggling has fascinated people for centuries. Seemingly oblivious to gravity, the skilled practitioner will keep several objects in the air at one time, and weave complex patterns that seem to defy analysis. In this talk the speaker demonstrates a selection of the patterns and skills of juggling while at the same time developing a simple method of describing and annotating a class of juggling patterns. By using elementary mathematics these patterns can be classified, leading to a simple way to describe those patterns that are known already, and a technique for discovering new ones. Along the way, we discover a few extra surprises...

Colin Wright graduated in Pure Mathematics at Monash University, Melbourne, before going on to get a PhD at Cambridge. While there he learned how to fire-breathe, unicycle and juggle. These days he is director of a company that specialises in software for marine radar, but takes out time to give juggling talks all over the world.

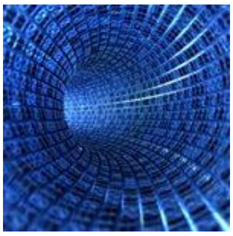
13/11/13
Maths in the making of the modern world
Professor Chris Budd (University of Bath)

We live in a world dominated by technology, from the Internet to the IPad and the mobile phone to GPS. Yet how many of us realise that all of this technology is based on mathematics, and that without maths the modern world would not exist.

In this talk Professor Budd describes the maths that makes internet giants like Google function, and is behind the programming of the iPod and the mobile phone. He will also show how maths had led to the modern information revolution. No previous knowledge of maths is needed, but please bring your imagination!

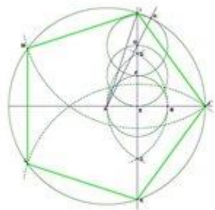
4/12/13
Pi, interstellar dust, and single-pixel cameras: some surprising uses for random numbers
Dr Iain Styles (University of Birmingham)

Randomly generated sequences of numbers are surprisingly useful tools that can help us perform complex calculations. In this talk, we will explore how random numbers can be used in a variety of ways: from a simple way to compute Pi, through modelling the propagation of radiation from stars through interstellar dust, to building imaging cameras that have only one pixel.



22/01/14
The surprising difficulty of using mathematics in computer science
Professor Achim Jung (University of Birmingham)

In 1959 the Noble Prize winner Eugene Wigner gave a talk with the title "The unreasonable effectiveness of mathematics in the natural sciences". A write-up is easily available on the Internet, but, briefly, Wigner argued that in the natural sciences, and in physics in particular, mathematics exhibits an "a priori" usefulness and he speculates why this should be so. In computer science we also use mathematical language and mathematical theories, but one should perhaps not speak so much of "applicability" of one to the other, but of a rich and constantly evolving relationship between the two disciplines. I will trace one instance of this relationship; that which starts with Church's lambda calculus in the 1930s and has since led to the development of programming languages such as Haskell.



5/2/14
Primes and Polygons
Dr John Silvester (King's College London)

The game of constructing geometrical figures with ruler and compasses was invented by the ancient Greeks. Most people know how to construct an equilateral triangle, or a square; it is harder (but possible) to construct a regular pentagon, and impossible to construct a regular heptagon. What is going on here? There is an unexpected connection between the values of n for which a regular n-gon can be constructed, and the prime factors of n. It has to do with the Fermat primes, numbers of the form 2m + 1, where as far as we know m must be 1, 2, 4, 8 or 16. Fermat thought m could be any power of 2, but Euler showed he was wrong.

100 million to 1: what can maths tell us about the Great Sperm Race?
Dr David Smith (University of Birmingham)

Reproduction is a numbers game! The average man produces over a thousand sperm every heart beat, yet only one is needed for fertilisation. Due to the pressing need for better ways to diagnose infertility, the subject is very important. This talk focuses on work bringing different areas of science together, led by Birmingham Women's Hospital, through which maths, combined with engineering and physics, are being applied to understand how sperm propel themselves through the tortuous maze of the female tract. We will look at both the fluid mechanics of microswimming and the migration of populations through complex microarchitectures, including the tantalising possibility that sperm might be guided to the egg. The guiding theme will be how maths and computing help us to understand the counterintuitive world that sperm encounter; the talk will also feature both high speed imaging of cells in microscopic mazes and human tract explants, and ‘virtual sperm’ supercomputing simulations.

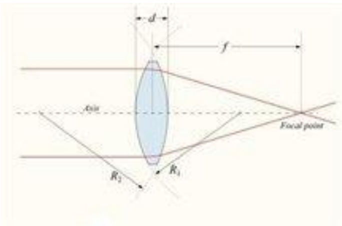
Past Birmingham Popular Maths Lectures (2012/2013)

05/12/12
How Round is Your Circle?
Dr Chris Sangwin (University of Birmingham)

Mechanisms are all around us. We often take them for granted, or don't even notice they exist. Most have a long and interesting history. Almost all such mechanisms rely on rotating parts. That is, one circular part which fits inside another. These need to be made very accurately to work safely, smoothly and without wearing out. This raises a basic problem which links engineering to mathematics. How do you test if something is round? I.e., how round is your "circle"? Sounds simple? The answer to this question turns out to be much more interesting than it first appears. It involves the shape of the 50p coin, the NASA Space Shuttle Challenger explosion in 1986 and how to drill a square hole.

16/01/13
How Big is Infinity?
Dr Chris Good (University of Birmingham)

Just how big is infinity? Bigger than you might think. It turns out that there are infinitely many infinities and that given any infinity there is a bigger one. In this talk we will prove that there are at least two infinities and along the way touch on ideas of Georg Cantor that split the mathematical community at the end of the 19th century.



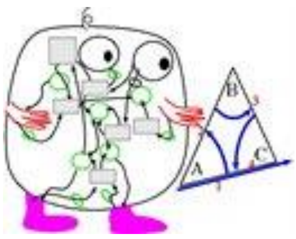
6/2/13
Mathematics Under the Lens
Dr Richard Kaye (University of Birmingham)

The first lens that successfully records straight lines in the subject as straight lines in the image was introduced simultaneously by Dallmeyer and Steinheil in 1866. Known as the "rapid rectilinear" or "aplanat" lens, it was a significant improvement on previous lenses. We will explore the geometry of transformations that preserve straight lines, and give a number of illustrations and creative techniques in photography that illustrate the use of rectilinear lenses. This talk will look at some of the geometry behind camera lenses.

13/3/14 "The Maths of Google"
Dr Richard Lissaman

Internet search engines and video graphics are both multi-billion pound global industries. And maths is at the heart of both of them. Google depends on simultaneous equations, while the graphics behind computer animated films and games require thousands of calculations involving triangles, angles and vectors. In this session we'll look at applications of school level mathematics in internet search engines and video games.

Richard Lissaman is Programme Leader of the Further Mathematics Support Programme. He has been a lecturer at Warwick University, and for a couple of years he also worked part time advising a computer games company in London. Richard has a PhD in algebra and is an author of maths textbooks.



17/4/13 "Could a Baby Robot Grow Up to Be a Mathematician?" Professor Aaron Sloman

Euclidean geometry is one of the greatest products of human minds, brought together in Euclid's Elements over two millennia ago. However, at some distant earlier time there were no geometry textbooks and no teachers. So, long before Euclid, our ancestors, perhaps while building huts, temples and pyramids, or making tools or weapons, or measuring fields, or reasoning about routes, must have noticed facts about spatial structures and processes that are not only useful, but, unlike facts of physics, chemistry and biology, are provable by reasoning, without having to keep checking that they remain true at high altitudes, or in cold weather, or on surfaces with unusual materials or colours. Without teachers to help, biological evolution must somehow have produced information-processing mechanisms that allowed ancient humans to develop the concepts, notice the relationships and discover the proofs that later humans normally encounter at school, but which we have the ability to discover for ourselves, as our ancestors did. All this suggests that normal human children have the potential to make those discoveries, under appropriate conditions. I suspect there are deep connections with competences that have evolved in other intelligent species that understand spatial structures, relationships and processes -- such as nest-building birds, squirrels working out how to get nuts from bird feeders, elephants that manipulate water, mud, sand and foliage with their trunks, and apes coping with many complex structures as they move through and feed in tree-tops. One way to demonstrate the feasibility of this conjecture is to try to design a robot that starts off with the competences of a very young child and develops in similar ways, extending those competences, and later perhaps being stimulated by the environment to make simple discoveries in Euclidean geometry -- unlike current geometric reasoning programs that use cartesian coordinate representations of geometrical structures. How to do this is not at all obvious. There have been great advances getting computers to reason logically, algebraically and arithmetically, but the kinds of reasoning in Euclid, e.g. using diagrams, are very different. I'll discuss some of the problems and possible ways forward. Perhaps someone now studying geometry at school will one day design the first baby robot that grows up to be a self-taught robot geometer, and, like some of our ancestors, discovers for itself why the angles of a planar triangle must add up to exactly half a rotation?