How math makes the world go round

Whether you're searching for oil, the lost chord or a better kind of carrot, mathematics is the key

By Ian Stewart, Telegraph Media UK 7:00AM GMT 27 Oct 2009

Math makes it: genetic breeding yields a better class of carrot

Like many amateur guitarists, I'd always wondered how to play the opening chord of A Hard Day's Night. Over the years, I spent hours trying to reconstruct it, but there was something very odd about it: no matter how hard I tried, I could never get it quite right.

In the end, the key to the mystery turned out not to be music, but mathematics. Five years ago fellow Beatles fan and mathematician Jason Brown of Dalhousie University analyzed the chord using a method called Fourier analysis, which splits sounds into their basic components. It turns out that the Beatles used a piano as well as their guitars.

It's not just music that has benefited from a little mathematical knowhow recently. On the sports pages, there has been a bit of fuss about a new type of soccer ball, which actually travels in the direction intended. What the reports don't say is that the design is based on a field of math called computational fluid dynamics, which uses complicated equations to work out how the air flows past the ball, equations which take into account not just the pattern of the panels, but even details of the seams.

That's the strange thing about math. Save for the odd occasion when you want to split the bill at a restaurant, it seems infinitely removed from everyday life. So it comes as a surprise to discover just how much math is lurking in everyday objects – such as soccer balls.

We know that math and technology go hand in hand: the inner workings of Google's search engine, for example, rely on several areas of advanced math, such as network theory, matrix algebra and probability theory. The researchers there are highly incentivized to make their work as accurate as possible: improve the math behind the equations, and oodles more cash floods in from more effective advertising.

But let's think about something more down to earth: a supermarket vegetable aisle, for example, and in particular, the carrots. The carrot is the second most popular vegetable in the world, after the potato. There are hundreds of varieties, differing in color, taste, resistance to disease, and ability to survive for weeks in a truck while being lugged across the country.

All of these types of carrot have been specially bred. One method is to cross-breed different varieties and see what you get; a more modern innovation is genetic engineering. Both rely heavily on math: it's used in the statistical calculations required to decide which breed is best, and in the design of the trials that provide the necessary information.

Now, I'd be the first to admit that when you are buying carrots, you don't need to do that sort of math. But someone has to, otherwise there wouldn't be any carrots for us to buy. Old-fashioned breeds don't work when you have to sell millions of carrots every day. No math, no veggies.

Anyway, once you've lugged that bag of carrots over to the car and dumped it in the trunk, you notice that you're nearly out of gas. No problem: the supermarket sells that, too. You don't need to know any math to stick the nozzle in your car – but without a lot of very difficult math indeed, there wouldn't be any gas in the pump.

In September (2009), British Petroleum announced the discovery of a massive new oilfield in the Gulf of Mexico, but you don't find oil seven miles down by drilling wells at random: you have to know where to look. Given an accurate map of the rock under the ground, geologists can recognize places where oil may be trapped. But how do you make that map? You make loud bangs at the surface and listen to the returning echoes. By doing the right math, you can then work out where the different layers of rock are.

It's a complicated problem, because the echoes from all the different layers of rock interfere with each other. It's a bit like trying to work out the street plan of a city by shouting loudly and listening to the sounds that bounce off the walls. It has taken decades of work by specialist mathematicians to come up with methods that are practical and accurate: one big oil company now does a quarter of a million of these complex calculations every day.

For centuries, math has been the main driver of science and technology, and the results have transformed our world. My wife and I have a new grandson, and a few months ago we were able to watch a DVD of him before he was born, made using an ultrasound scan. This employs sound that is so high-pitched that the human ear can't perceive it. And it works much like oil exploration: the equipment listens to the echoes, and uses math to reconstruct the shape that must have produced them.

Modern medicine uses many different scanners – CT scans, PET scans, ultrasound. Their common feature is that they use math to calculate the shape of whatever is being scanned, by analyzing the signals that the equipment is designed to detect. The mathematical basis of CT scans was worked out more than a century ago by Johann Radon, a pure mathematician who had no idea that his work – suitably tweaked – would routinely save lives long after he was dead.

Today, medical researchers are developing mathematical ways to detect cancer more accurately. Under a microscope, cancer cells look different from healthy cells, but it takes a trained eye to tell the difference. The mathematics of fractals – very complex geometric shapes – is just what the doctor ordered, helping to capture the difference between the shape of a healthy cell and a cancerous one.

As if that wasn't enough, math plays a big part in keeping the environment healthy, too. An example is climate change. Even to detect it, you have to compare what is actually happening with what would have happened if the planet had been left to its own devices. But we can't rerun the planet's history, so we have to deduce what would have happened without human intervention. One way we can do that is to model the climate mathematically.

So yes, our fancy electronic gadgets – mobile phones, DVD players, digital cameras, the internet, satellite navigation– rely on a lot of math. And yes, we use it to make sure that aircraft stay up, Formula 1 cars drive very fast, and gigantic towers don't collapse. But we seldom realize the extent to which math has invaded every corner of our lives. It shows up in politics, in opinion polls and focus groups. It controls traffic lights, gets crowds safely into and out of sports stadiums, designs the lenses in our glasses.

And the reason we don't notice it is that, entirely sensibly, the math is kept behind the scenes. If I'm buying carrots, I don't want to have to learn about the mathematics of genetic trials. If I'm putting gas in my car, I don't need to know how to solve the inverse problem for seismic waves. But if I want to understand how my world works, I do need to appreciate that the math is there. Otherwise, I'll think that the subject is useless. And if too many of us do that, soon there won't be enough mathematicians to keep everything working.