My research lies somewhere between pure mathematics and theoretical 'high-energy' physics, which means the physics of very small things, millions of times smaller than atoms.

Physical theories have to be expressed in the language of mathematics, so mathematical tools and concepts have to be developed before a physicist's ideas can be made precise. For example, when Newton developed his theories of gravity and motion, he first had to invent the mathematical technique of calculus. Without the idea of the derivative of a function, his equations can't even be written down properly, much less solved.

Sometimes in history, the maths has been ahead of the physics. This was true for example when Einstein was inventing General Relativity, all the maths he needed had been developed a few decades earlier, mostly by the great German geometers Gauss and Riemann. Today however, the physics is ahead of the maths - physicists have ideas, and some calculational techniques, that are beyond what mathematicians can currently understand and make precise. This is great news for mathematicians, because studying the physicists' work leads to lots of interesting new mathematics.

Most of this new maths is linked to a particular physical idea, called String Theory. String Theory is controversial amongst physicists, because despite having been around for about thirty years and having lots of people working on it, it hasn't yet developed into a proper theory that can be tested against experiments. This is mostly because the maths is still lacking! So what String theorists (and mathematicians like myself) are still doing is developing the mathematical language with which the theory can be described. Fortunately even if String Theory turns out to be wrong, then whatever the correct theory is will undoubtedly still use this same mathematical language. And for mathematicians, this language is very interesting and beautiful in its own right.

The fundamental idea of String theory is that instead of thinking of electrons, protons, etc. as 'particles', like little tennis balls, we should think of them as little vibrating pieces of 'string'. The advantage of this is that a single piece of string can vibrate in lots of different ways, like a string on a violin playing different notes. This means that we don't need lots of different kinds of particles, we just need one thing: strings. When we see an electron, it's a string playing one kind of note. When we see any other particle, it's the same kind of string, it's just playing a different note.

Strings can be formed into loops, like rubber bands, but if they're not then the ends of the string have to be attached to something. What they attach to are objects called 'branes', short for 'membranes', which are a bit like sheets of rubber (although they might really have many more dimensions). The branes themselves can also move around, and this makes the theory much more complicated and interesting.

In my research, I study a particular kind of brane, called a 'B-brane'. The maths that's needed to describe B-branes turns out to have lots of connections to many other parts of mathematics, including to lots of areas that previously had nothing to do with physics, such as abstract algebra and algebraic geometry. So as well as laying the foundations for the physics, we can use physical insights to learn new things about these areas of pure maths.