



## The Science of *The Infinite Lives of Maisie Day*

There's a lot of fascinating science in *The Infinite Lives of Maisie Day*, from the Big Bang that started the universe to what exactly you'd find inside a black hole. Some of these ideas can stretch the brains of real-life scientists, so let's take a look to find out more!

We'll start with something simple: What exactly is the universe?

The universe is everything that exists—all the stars and galaxies in the sky—and when you look at it now, it's pretty big. But most scientists think that our universe started out as a tiny seed—a minuscule speck of space-time a trillion trillion trillion times smaller than a grain of sand. This tiny seed contained all the energy and matter that would eventually create everything in the universe.

And 13.8 billion years ago, this tiny speck of space-time suddenly got very big, very fast in a cosmic event scientists call the Big Bang.

**So could you say this was some kind of intergalactic rock concert?**

Not quite. The Big Bang was a super-hot explosion that started the universe. In less than a second, the universe grew from a tiny speck the size of a subatomic particle to a space thousands of miles across. And since then it has just kept on growing. We can only see the bit of the universe whose light has had the chance to reach us since the Big Bang. This is called the observable universe. It measures 93 billion light-years across and contains trillions of galaxies, but the whole universe is much, much bigger than that. Scientists are still working on understanding the ongoing expansion of the universe.

**Does the universe go on forever?**

We don't know. Some scientists think we might live in an infinite universe that stretches on forever in every direction, but others believe the universe must be finite and just have a particular shape that makes it look like it's infinite. According to these scientists, the universe might



be shaped like a four-dimensional sphere or a saddle or even a doughnut!

Mmmm, round like a doughnut ...



This doesn't mean that our universe could be devoured at any second by an infinite number of four-dimensional Homer Simpsons. A weird doughnut-shaped universe would appear to be infinite because you could never reach the edge of it. If you traveled far enough in any direction, you'd just end up back at the point where you started.



Like a Möbius strip?



That's right. And you can even make a Möbius strip yourself to check this out—all you need is a strip of paper. A normal piece of paper has two sides: the front and the back. But if you give a strip of paper a twist and then join the ends together, you've created a Möbius strip. If you get a pen and draw a line down the center of your Möbius strip, you'll end up going twice around the loop before you reach the point you started from. And that's not the strangest thing. If you were able to walk around this loop of paper holding an egg in your right hand, by the time you got halfway around the Möbius strip you'd find that



you were holding the egg in your left hand instead. Walking around the Möbius strip would turn you into a mirror image of yourself.

**Wow! That's amazing!**

There's more. . . . The egg you're holding is made out of atoms. That's not a surprise. Everything in the universe is made out of atoms. But at the moment, all the atoms in your egg are arranged in a particular way. This makes it, well, egg-shaped.



**Oops! Er, I'm afraid I dropped the egg. . . .**



Don't worry, I *knew* you were going to do that. But the smashed egg is still made of exactly the same atoms as before, only now they're disorganized and random. This means the *entropy* of the egg has increased.

**Entropy is how random and disorganized something is.**

Right. When the egg was whole, its atoms were arranged in a highly organized way, but when you dropped the egg, there were many different ways in which it could break. The atoms in this bit of shell could have ended up over here or over here or over here. There were so many

different ways its atoms could be arranged—but it would still be a broken egg. Or think about an ice cube, where all the molecules are arranged to create a perfect cube shape. If you melt the ice cube, the molecules are able to move around more freely as a liquid. This means its entropy has increased. In the universe, entropy is always increasing. This is the second law of thermodynamics.

### Thermodynamics?

*Thermodynamics* is a big word that means the bit of science that's all about heat and other forms of energy. The second law of thermodynamics says the level of disorder in the universe is steadily increasing. Eggs break, ice melts, stars burn themselves out and sometimes even become black holes.

### Black holes! How could I make a black hole?

Black holes are created when a giant star dies. After using up all the fuel that powers the process of nuclear fusion, the heart of the star collapses in upon itself, causing a massive explosion that blasts part of the star into space. All the matter that's left then gets squeezed into a tiny point to create a black hole. The gravity inside a black hole is so strong that nothing can escape. Not even light.

And if you get too close and cross the *event horizon*—the boundary in space beyond which there’s no escape from the black hole’s gravity—then you’ll find yourself falling into a bottomless pit.

You’re kind of scaring me. So what exactly would happen if I fell into a black hole?

The immense gravity of the black hole warps space-time so much that the closer you get to a black hole, the slower time goes. You wouldn’t necessarily notice time slowing down as you fell in, as the gravitational forces would stretch and squeeze you into a long, thin shape, essentially turning you into spaghetti!

What if I managed to escape being turned into spaghetti?  
What would I find inside the black hole?

Let’s say you somehow survive this “spaghettification” and reach the heart of the black hole. There you’ll find a point of infinite density—a tiny speck even smaller than an atom—where time and space come to an end. This is called the *singularity*.

Wait a second—a tiny speck even smaller than an atom?  
Isn't that where we started before the Big Bang?

That's right. And that makes some scientists think our universe might even have been born inside a black hole in another universe. Like Maisie says, from the outside our universe might look infinitely small, but to us on the inside it would look infinite.

Science explores the big questions about life, the universe, and everything—the same questions that can underpin the very best stories. Why are we here? What makes us human? How do we know we really exist? My other two novels, *The Many Worlds of Albie Bright* and *The Jamie Drake Equation*, are also inspired by scientific theories. I hope these stories help you to understand more about the world we all live in and inspire you to build a better one.