CHRISTIAN GRALINGEN

THE ORIGIN OF MATHEMATICS

It's our most effective tool for understanding the universe. But where it comes from and how it developed remain mysterious, finds Anil Ananthaswamy

TO THE Iranian mathematician Maryam Mirzakhani, the first woman to win the Fields medal, mathematics often felt like "being lost in a jungle and trying to use all the knowledge that you can gather to come up with some new tricks".

"With some luck," she added, "you might find a way out."

Mirzakhani, who died on 14 July at the age of 40, ventured deeper into the mathematical jungle than most. Nonetheless, most of us have spent enough time on its periphery to have a sense of what the terrain looks like.

Increasingly, it seems as if humans are the only animals with the cognitive ability to hack their way through the undergrowth. But where does this ability come from? Why did we develop it? And what is it for? Answering these questions involves diving into one of the hottest debates in neuroscience, and reimagining what mathematics really is.

The natural world is a complex and unpredictable place. Habitats change, predators strike, food runs out. An organism's survival depends on its ability to make sense of its surroundings, whether by counting down to nightfall, figuring out the quickest way to escape danger or weighing up the spots most likely to have food. And that, says Karl Friston, a computational neuroscientist and physicist at University College London, means doing mathematics.

"There is a simplicity and parsimony and symmetry to mathematics," says Friston, "which, if you were treating it as a language, wins hands down over all other ways of describing the world." From dolphins to slime moulds, organisms throughout the evolutionary tree seem to make sense of the world mathematically, deciphering its patterns and regularities in order to survive.

Friston argues that any self-organising system – and so any form of life – that interacts with its environment needs an implicit model of that environment to function. The idea goes back to the 1970s and the "good regulator" theorem, co-developed by Ross Ashby, who pioneered the field of cybernetics. To provide effective control, the theorem says, a robot's brain must have an internal model of its mechanical body and its environment. "That insight is becoming increasingly formalised now in machine learning and artificial intelligence," says Friston. The corollary being that an animal's brain, too, must model its body and the world in which it moves.

No thought required

The remarkable thing is that none of these creature modellers are aware of what they're doing. Even we human beings, when we run to catch a ball or dart through heavy traffic, are unconsciously doing some pretty complex mathematics. Each of our brains is constantly using its models to predict what we'll encounter, says the theory, and these models are kept updated by checking the predictions against actual sensations.

Those mathematical functions are undoubtedly being computed by particular bits of the brain, says Andy Clark, a cognitive philosopher at the University of Edinburgh, ›