Introduction

Jayant Narlikar, then Professor of Astrophysics at the Tata Institute of Fundamental Research in Mumbai, India, opened his 1977 book *The Structure of the Universe*[a] with this particularly witty anecdote:

> *Once upon a time an astronomer, a physicist, and a mathematician set off on a walking tour in the Scottish highlands. They soon came across a sheep grazing all alone on a farm. Looking at it the astronomer commented 'So, the sheep in the highlands are black.'*
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> *'You cannot generalize so sweepingly', admonished the physicist. 'Your sample is too small. Only after a careful analysis of a large number of sheep all over the highlands can you make such a statement. Just now all you can say is that black sheep are found in Scotland.' He turned to the mathematician for his views.*
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> *'I am afraid I disagree with you both', remarked that worthy. 'All you can say is that the animal over there appears to be black on the side facing us.'*

Brilliant. And all the more so because it tells us something true about ourselves as human beings… we all see the world differently. *'The map of what we call reality is an ever-shifting mosaic of ideas.'*[b] So writes physicist and 'natural philosopher' Marcelo Gleiser, but one map of reality that has not shifted to the left or right in more than 130 years is that described by English schoolmaster Edwin Abbott Abbott in the most entertaining work on geometry ever written, *Flatland: A Romance of Many Dimensions*.

Geometry (a subject that needed livening up no doubt) holds great significance for those of us who simply can't help prying into the secrets of the universe. Einstein's contemporary, the philosopher Hans Reichenbach, informed us that *'the philosophers of all ages have regarded it as their highest aim to prove their conclusions "by the geometrical method."'*[c] And, of course, Albert Einstein couched Relativity in terms of it. So, if life, the universe, and everything turns out to have some kind of undergirding structure, we should not be surprised to find geometry in there someplace.

In his book, *Our Mathematical Universe*, MIT cosmologist Max Tegmark[d] sets out to describe what he calls *'a crazy-sounding belief of mine'* that our physical world not only is *described* by mathematics, but that it *is* mathematics, *'making us self-aware parts of a giant mathematical object.'*[e] Whether or not that object relates to the dimensional structure as described in this book remains to be seen, but it seems to me that the profound simplicity of EA Abbott's *Flatland* is a great place to start. After all, not only has it been in print since 1884 (which tells us something) but it has been employed by scientists going right back to Einstein, who, although he did not directly credit Abbott in his 1916 popular work *Relativity*, deployed the little Flatlanders to great effect assuring us that *'the three-dimensional spherical space is quite analogous to the two-dimensional spherical surface'*[f]. So we see that there is nothing new or strange in the application of *Flatland* principles to the universe.

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[a] Jayant Narlikar, *The Structure of the Universe*, Oxford University Press 1977
[b] Marcelo Gleiser, *The Island of Knowledge*, Basic Books 2015, Pxiv
[c] Hans Reichenbach, *The Philosophy of Space and Time*, Dover 1957, P1
[d] Described by the *Daily Telegraph* as a 'rock god' cosmologist – I'm sure Brian May would approve!
[e] Max Tegmark, *Our Mathematical Universe*, Penguin 2015, P6
[f] Albert Einstein, *Relativity, Appendix 5*, Routledge 2001, P151. Note that Einstein's (translator's) use of the word 'quite' would be in the old sense of 'exactly', rather than the modern sense of 'roughly'. I suspect that rough analogies would have been of little use to him.

Powerful as mathematics is, attempts to prise open the world purely on its terms appear to have run into problems. It may have cast its net too wide. Einstein wrote in 1944, *'So many people today – and even professional scientists – seem to me like somebody who has seen thousands of trees but has never seen a forest... In looking for a new foundation, [the physicist] must try to make clear in his own mind just how far the concepts which he uses are justified, and are necessities.'*[a] The time has come to have confidence in analogy, and thereby attempt to gain an understanding of why certain processes apply to reality where others don't.

What we are about to do – without tampering in any way with Relativity or Quantum Mechanics – is push the principles of *Flatland* to their logical conclusion. Instead of, as is the norm, simply applying them sparingly in areas where we feel confident they apply, we will attempt a rather grand experiment: laying down the principles of *Flatland* <u>as ground rules for the whole of reality</u> – up to and including human perception, because, as the esteemed English mathematician Sir Roger Penrose writes, *'Whatever it is that controls or describes the mind must indeed be an integral part of the same grand scheme which governs, also, all the* **material** *attributes of our universe.'*[b]

Self-aware parts of a giant mathematical object we may be, but, surprisingly, if it has its basis in *Flatland* it may not be a complicated object. The great US physicist Richard Feynman told us that *"In the case of the chess game, the rules become more complicated as you go along, but in the physics, when you discover new things it looks more simple."*[c] The years since *Flatland* was written have seen the discovery of many new things, therefore, let us embark on EA Abbott's dimensional trail and simplify.

Following Tegmark's mantra we will now *'Dare to extrapolate!'*[d] and – from beginning to end – little *A Square* and his highly knowledgeable 3-Dimensional friend, *Sphere* shall be our guides…

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[a] http://plato.stanford.edu/entries/einstein-philscience/#ReaSep - Accessed 27th Apr 2017
[b] Roger Penrose, *Shadows of the Mind*, Vintage Books 2005, P213 (Emphasis his)
[c] http://www.dailymotion.com/video/x24gwgc_richard-feynman-the-pleasure-of-finding-things-out_news - Accessed 26th June 2016
[d] Max Tegmark, *Our Mathematical Universe*, Penguin 2015, P50