Chapter 1

2D, or Not 2D?

It is no mystery that life as we know it has several dimensions. If you have ever considered buying a piece of furniture from a catalogue you will immediately have been confronted by three of them: length, width and height. These three are what scientists refer to as the *three dimensions of space*, the *spatial dimensions*, or occasionally just *'the usual three'*.

3D is big in the cinemas these days and, although in that setting it is just a clever technological illusion, we all get the picture – the universe is 3D. However, there is another dimension, a fourth, that we must factor into the equation. Bit strange that one – wasn't mentioned in the catalogue... well funnily enough it was, because if you did order the item you will no doubt have been concerned with how long they took to deliver. That's because time behaves as a fourth dimension, the means by which everything around us constantly changes, although for some reason we can only move in one direction through time. There is absolutely nothing strange or controversial about this. It is basic physics.

But, we might reasonably ask, if there are four dimensions why can't there be five? Unfortunately for most of us, as Michael Palin dutifully read from the *Book of Armaments* in the classic 1975 film *Monty Python and the Holy Grail*, ***"Five is right out!"*** We humans are simply not mentally equipped to visualise higher dimensions. But this doesn't mean they're not there – only that we can't picture them. Which leads us inevitably to one of two things:

1) Magic, or
2) Mathematics

Magic:

A glance at any newsstand will tell you how popular this is – I counted nine magazines on astrology, destiny and angelic wonderfulness just in our local newsagent! Higher dimensions have no need of logic when it comes to the emotional side of human experience. We wander where we will, through Elysian fields and esoteric planes… all that is required is that we feel it, and believe it. But belief of itself, without any attempt to understand the foundation of that belief, can be a dangerous thing. Those who are offended by that thought will have no need of this book.

Mathematics:

We live in a 'Goldilocks' universe in which all the parameters and constants appear finely tuned for us to be here, and dimension numbers are no exception. UK Astronomer Royal, Martin Rees tells us that,

> *'With four spatial dimensions the orbits of planets would be unstable, while life would be impossible with just two.'* [a]

Scientists play around with the figures all the time and for them the existence of a fifth dimension is perfectly plausible. The German mathematician Theodor Kaluza blew Einstein's mind (no mean feat) in 1919 when he demonstrated on paper that by adding a fifth dimension to the theory of Relativity he could derive the electro-magnetic equations of Scots genius James Clerk Maxwell (Einstein's hero), thus uniting

[a] New Scientist/The Collection, Vol 1 Issue 1, 2014, P27, extracted from: Martin Rees, *Just Six Numbers*, Phoenix 2001

the two great theories of the time. Unsure what to make of it, Einstein faffed about for two years, then, much to his chagrin Kaluza's insight went on to be overshadowed by the breakthroughs of Quantum theory. To this day a precise understanding of this extra dimension's relationship to reality, if any, is still somewhat up for grabs.

Frustratingly for the layperson, higher dimensions are now the exclusive domain of mathematicians and physicists who wrestle with complex equations and concepts via String theory: an umbrella term for as-yet purely mathematical structures comprising 10, 11 or perhaps even 26 dimensions.

But there is something about the possibility, the whole idea, of higher dimensions that tugs on us all – something perhaps *only just out of reach…*

Flatland

In the mid 1880s, whilst Albert Einstein was still running around Württemberg in little leather breeches, a highly respected English schoolmaster with an interest in theology, literature and mathematics wrote a book. A short, but intriguingly different book. His name was Edwin Abbott Abbott (yes, two Abbotts) and the book was called *Flatland: A Romance of Many Dimensions.*

EA Abbott, 1838-1926

EC85 Ab264 884f, Houghton Library, Harvard University

Although written in the tiresomely long-winded style of the Victorian era, *Flatland* is still read today, with around 3,000 reviews on *goodreads.com!* A film version[a] came out in 2007 which is used in schools – to the great delight of the young who extol it online for its power to relieve maths of its duty to be boring.

Frequently referred to by scientists such as Carl Sagan, Stephen Hawking, Janna Levin, and Michio Kaku, *Flatland* is commended for its accurate description of the viewpoint of theoretical 3D, 2D, 1D, and even zero-Dimensional beings who happily populate Spaceland, Flatland, Lineland and Pointland respectively. I hope that Dr Abbott would not mind, but much of this book is based on his text as it brings what might otherwise be an exercise in boring geometry (perish the thought!) to life. And since physicists Brian Cox and Jeff Forshaw tell us that, *'Einstein's theories can be constructed almost entirely using the language of geometry,'*[b] we are in good company.

As we progress, we will discover that what EA Abbott referred to as 'Dimensionality' could potentially be a key to unlock a whole new paradigm of nature, because many of the deepest mysteries of our time find a clear and consistent place within his structure. Mysteries such as:

- The role of time
- The Cosmological Principle
- Observer-centricity
- The shape of the universe
- Infinity and cosmic horizons
- Gravity and 'repulsive' gravity (dark energy)

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[a] *Flatland*, Directed by Ladd Ehlinger Jr, 2007

[b] Brian Cox & Jeff Forshaw, *Why Does $E=mc^2$?*, Da Capo 2009, P58

- ‘Before’ the Big Bang, and
- The phenomenon and diversity of life

Alongside new concepts such as:

- 2D equatorial lensing
- *Centre A/B* recession
- The *Centre B/B* information lag
- A geometry of reproduction, and
- Non-storage memory

These insights and more – none of which are machine-gunned speculations contrived for controversy, but clear and integral parts of a single, logically reasoned framework – are all based on the simple and entertaining *Flatland* fundamentals we are about to consider. Obviously if you haven’t already read *Flatland* you may read it if you wish – it is in the public domain and available online[a] – but this is certainly not obligatory as the geometrical principles themselves are not complicated and the thrust will become clear as we go. But just to get us started, here’s a brief summary…

Upwardly Mobile

The chief protagonist and ‘author’, a square shape by the name of *A Square* (which clever pun would no doubt have had the Victorians rolling in their parlours) inhabits a 2-Dimensional world populated by geometric shapes – the Flatlanders – with varying lengths and numbers of sides ranging from extremely pointy ‘lower class’ isosceles triangles to near-perfect ‘upper class’ circles.

As the book progresses, Dr Abbott presents a meticulous description of *A Square’s* native land which has length and width, but no height. This he wisely opts to call Flatland for the simple and obvious reason that everything about it – the people, the buildings, even the weather – is flat. All 2-Dimensional. This is the ultimate 2D world. Having said that, the limitation of its 2-Dimensionality is not something that the Flatlanders are aware of. *A Square* informs us,

> *“I call our world Flatland, not because we call it so, but to make its nature clearer to you, my happy readers, who are privileged to live in Space.”*

The people are all regular geometric shapes – triangles, squares, pentagons, hexagons and multi-sided polygons – and a rigid geometrical Caste system exists wherein one’s social position is set in place for a lifetime by the number and regularity of sides one is born with. Those polygons who have so many sides that they appear to be virtually perfect circles are considered the aristocracy, and are educated accordingly in preparation for their exalted roles in society.

At this point, in true Victorian style, I feel it my courteous duty to presage (a Dickensian word for warn) any prospective female readers of *Flatland* that it is written, not merely in the form of mathematical allegory, but also as a satirical commentary on late Victorian society. The tale reflects the era in which it was written, and although *A Square* does on a couple of occasions consider telling his wife about *the entire plotline*, he decides against it. In terms of social geometry, the women are all reduced to the status of lines[b]. As Abbott puts it, *“if a Soldier is a wedge, a Woman is a needle”*. As a result – being pointy at both ends – the women are lethal when angry! They are also dangerously invisible from certain angles and many a

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[a] http://www.eldritchpress.org/eaa/FL.HTM - Accessed 25th July 2017

[b] The lines are actually long, thin, pointed parallelograms.

domestic fracas has resulted in mayhem and carnage, although, happily, the Flatlanders are not entirely strangers to harmony in the home… Dr Abbott informs us, *"There is peace, in so far as the absence of slaughter may be called by that name"!*

In spite of the fact that the Flatland women are not credited with vast swathes of intelligence (*"I have actually known a case where a woman has exterminated her whole household and half an hour afterwards, when her rage was over and the fragments swept away, has asked what became of her husband and children."*) I would add that the Reverend himself is not in favour of the truncated social status of women in the Victorian era, and – as with all the social satire in the book – actually intends his volume as an exposé of injustice. However…

Interesting though *A Square's* fledgling middle class observations are, it is solely the dimensional attributes of *A Square* and his 2D world that we are concerned with here.

I will list some of them:

- He has only length and width, no height (sometimes called depth or thickness)
- He can never see things from above, as 'above' does not exist
- With his horizontal vision, he views everything 'edge-on'
- All shapes in his world appear to him as a line
- Lines have no thickness but simply appear (for some reason) bright
- Lines have varying widths depending on their distance from him
- He cannot tell other shapes apart as he cannot visually distinguish sides
- His house door is invisible to him as the back wall appears to merge with the front
- He has learnt to discern angles by touch
- He has no bodily orifices as his digestive tract would divide him in two!
- And last but by no means least, the women have to (by law) utter a constant *'Peace-cry'* as they go about their business because, being to all intents and purposes straight lines, from the front they are a virtually invisible dot! In the absence of this cry, many a Flatlander has been unwittingly and accidentally speared to death.

On the plus side, kindly Abbott assists poor old *Square* by making Flatland a foggy place. The constant mist enables him to roughly determine distance and shape, and the edges of the variously shaped Flatlanders may be discerned in the mist by how much they fade out, thus revealing their identity. Education in Flatland consists in learning to use the mist in this way, an academic subject which goes by the name of *'Sight Recognition'* as the landed gentry – i.e. the Circles – are particularly concerned with shape.

Revelation

One fateful night, after falling asleep whilst trying to get his head round some thorny yet highly enjoyable geometrical conundrum, *A Square* has a dream. In this dream he pays a surprise visit to a strange realm which goes by the name of Lineland. As its name suggests, Lineland is just a very long line, and a line has only one dimension: length. It is therefore a whole dimension below his own 2D Flatland, because a line is 1D.

Square is privileged to meet the *King of Lineland*. A 1-Dimensional character if ever there was one, the *King* is a line-segment individual who exists as a small section of the line that comprises his entire world. And he is not alone, but has all his minions on both sides of him all strung out along the line: men,

women and little liney children. Of course the *King* doesn't actually see them as lines because, although he has an eye at both extremities of his long and infinitely slender body, he can only see the ends of the two subjects next to him. Just as *A Square* sees all the shapes in Flatland edge-on as lines, the *King of Lineland* only sees his two nearest subjects point-on as zero-Dimensional (0D) points.

So how does he know they are all there? Well he wouldn't, but for the foresight of the author who, for the purposes of the book, gave them all uniquely individual singing voices which vibrate along the line (a kind of early String theory!) by which each line-being can tell who and where on the line everyone else lives.

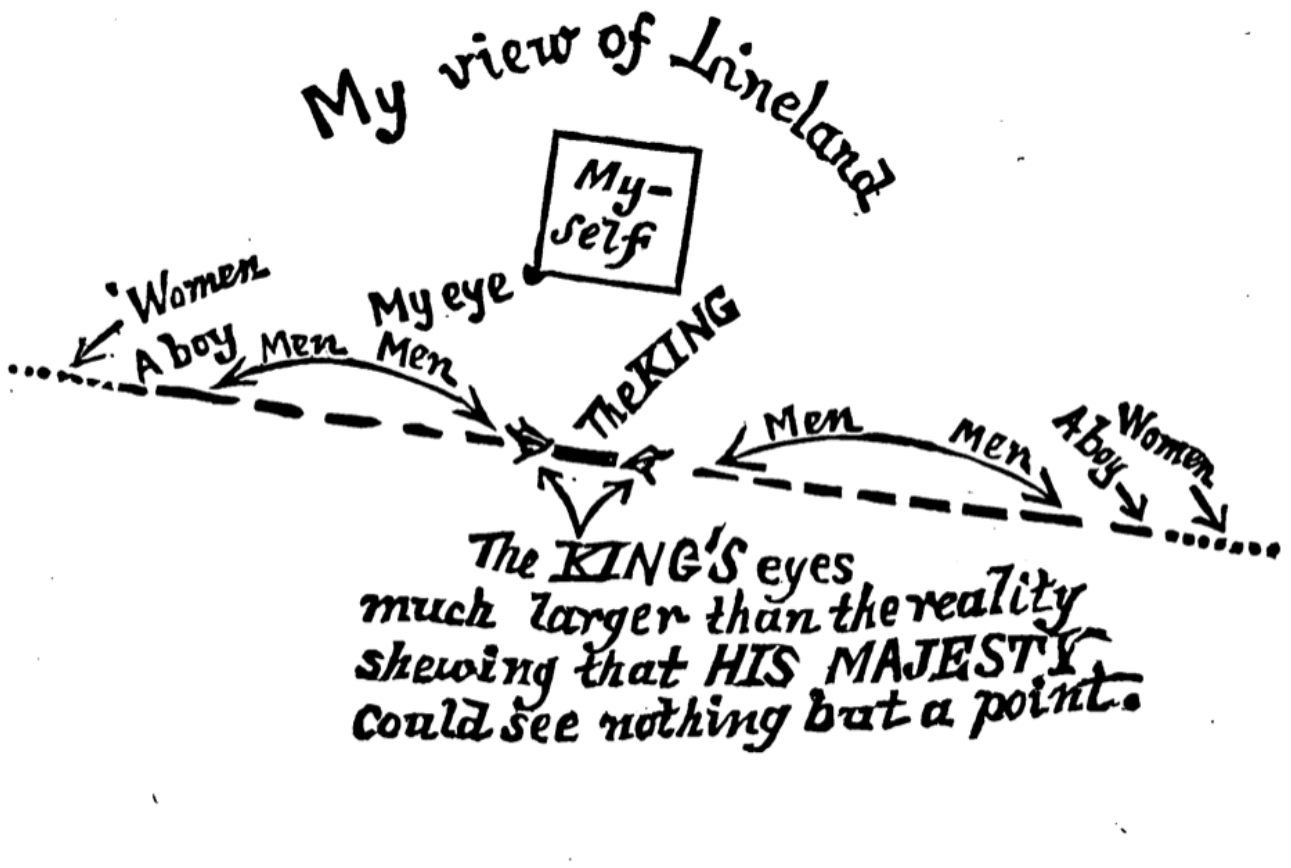

Fig.3 EA Abbott's rather complicated original drawing of his visit to Lineland, again replete with social comment.

Sadly for the old *King*, in spite of the fact that he possesses all the authority and splendour of a Renaissance pope, he cannot actually see 2D *Square*! He can hear his bizarre, muffled voice coming as it were from his *"own intestines"*, but that only serves to freak him out. He resorts to pulling rank, *"I am the Monarch of the world,"* declares he in a move reminiscent of King Canute's invention of the deckchair, but this proves futile. *Square* then reveals himself by holding his mouth to the *King's* world. However, as *Square* enters Lineland and passes his flat 2D body through, the *King* perceives him as *another line*. The 1D *King* sees only the bit that is on his line because that's the only part of *A Square* that appears in his world.

Square has many questions for the *King of Lineland* but, being a bloke, the first thing that springs to mind is to enquire as to how he and his subjects – stuck as they are in the same place on the line for a lifetime – conceivably manage to reproduce. The monarch replies…

> *"…the birth of children is too important a matter to have been allowed to depend upon such an accident as proximity."*

Priceless. *A Square* perseveres with his noble efforts at revelation, attempting to share what his own realm is like, but is forced to awaken when the great 1D *King* utterly fails to get one single thing about 2D Flatland until, overwhelmed by fear of the unknown, the whole of Lineland with *'the roar of an army of a hundred thousand Isosceles'* charges upon him to run him through!

But Edwin Abbott Abbott is not finished with poor unsuspecting *Square*, because the little Flatlander is about to receive a shock visit from a denizen of the 3rd Dimension… which is of course, to him, a higher dimension. EA Abbott's Spaceland is likened to our world: 3D, possessing our standard three dimensions of length, width and height. Continuing the mathematical theme, Flatland's gate-crasher turns out to be a talking sphere which just totally blows *Square's* mind – he thought circles were high-born! This is where the *Romance of Many Dimensions* really starts to kick off…

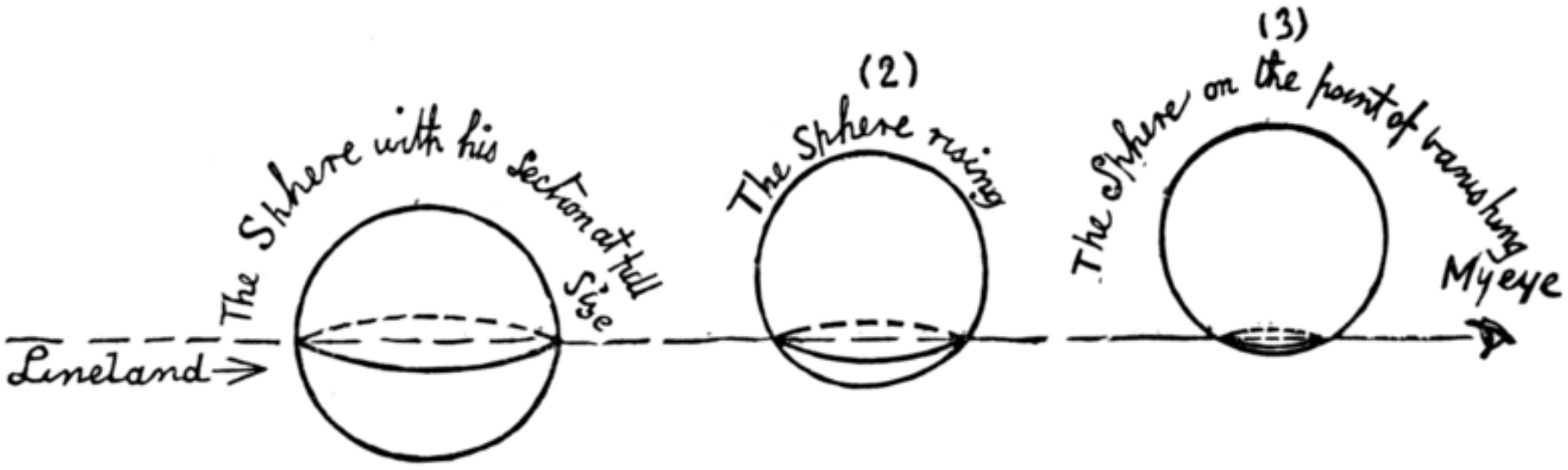

Fig.4 EA Abbott's original drawing of *Sphere's* progress as a cross-sectional disk ('Circle') through Flatland.
(Made unnecessarily confusing by his inclusion of Lineland!)

To *A Square's* utter astoundment, *Sphere* simply appears out of nowhere as he descends through Flatland (actually he rises up through Flatland but the effect is the same). *Square* doesn't perceive him as a sphere though, because to *Square*, *Sphere* appears as a line with smoothly fading edges – which in his world is a circle, edge-on. The reason he appears this way is that ***only a 2-Dimensional cross-section of the sphere (a circle) can be seen from within Square's 2D world.***

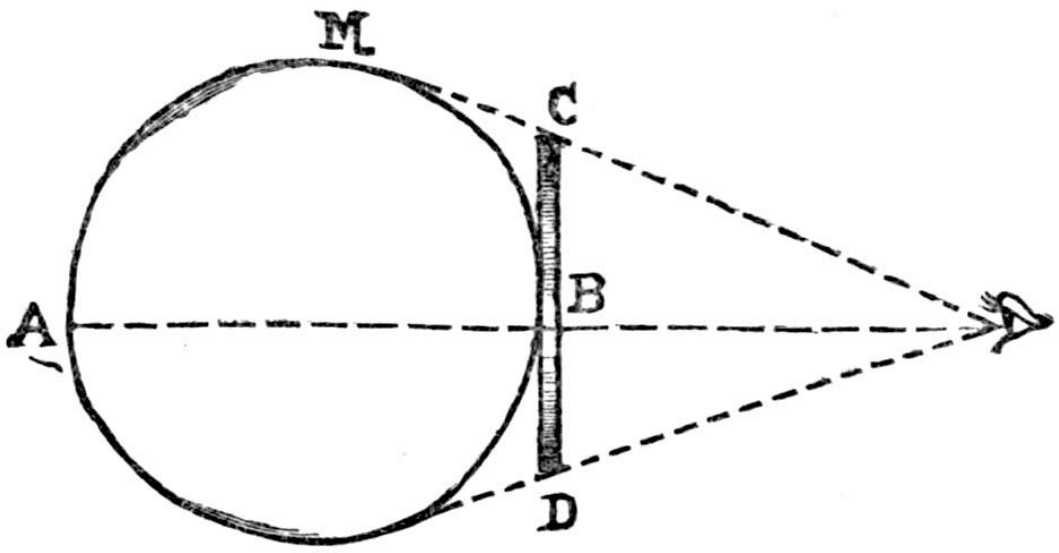

Fig.5 EA Abbott's original illustration of how a bumpy circle (or flat disk) appears to a Flatlander as a line.

To make matters worse for old *Square*, *Sphere* appears first as a tiny circle, which grows steadily to a *wide* circle before shrinking back down and disappearing completely from *Square's* view like the dot that used to signal the end of an evening's viewing on an old black and white TV set.

What just happened?

"I am many Circles in one," announces *Sphere*, as he passes right through Flatland and pops out the other side! Although *Square* doesn't see the connection at first, *Sphere* has done exactly what he himself did in his dream when he passed through Lineland. Just as *Square* passed through Lineland in cross-sectional lines, so *Sphere* passes through Flatland in cross-sectional circles.

This applies uniformly across all three dimensions, because it embodies a basic geometrical principle. *Sphere* explains,

> *"I am not a plane Figure, but a Solid. You call me a Circle; but in reality I am not a Circle, but an infinite number of Circles, of size varying from a Point to a Circle of thirteen inches in diameter, one placed on the top of the other. When I cut through your plane as I am now doing, I make in your plane a section which you, very rightly, call a Circle. For even a Sphere – which is my proper name in my own country – if he manifest himself at all to an inhabitant of Flatland – must needs manifest himself as a Circle."*

Much jolly geometrical banter ensues between them. However, completely unable to conceive the concept of a third dimension in spite of *Sphere's* tireless allusion to example and metaphor, *A Square's* frustrations finally boil over. With the words, *"Monster, be thou juggler, enchanter, dream, or devil, no more will I endure thy mockeries,"* like the Pharisees of old he finally resorts to violence. Fortunately for us, *Sphere* has his measure…

The Magical Mystery Tour

It was extremely disconcerting for *A Square* to be confronted by a higher dimensional being. It freaked him out because it defied his comprehension and he felt utterly powerless in the situation. Not only could *Sphere* turn himself 'invisible' at will simply by withdrawing a short distance up or down from *Square's* 2D plane, but he could talk to him from out there without being seen. *Sphere* goes on to demonstrate a few more of his 'powers'…

Sphere can see the layout of the whole town and what every Flatlander is doing. Without even requiring to be in *Square's* world he can see behind walls and into locked chambers. He can even see *A Square*'s insides! At this realisation *Square* begins to be fearful lest this strange and alien being should choose to materialise *within* him. Which, later on, he kind of does. Ouch! *Square* then goes on to experience all these powers first-hand as *Sphere* lifts him right up out of Flatland into Spaceland (from 2D into 3D) and shows him his own familiar flat universe from *Sphere's* perspective. As might be expected, *A Square* views all this with awesome, super-real clarity and eventually returns armed with the knowledge of what his family and friends were saying and doing whilst he was gone. This evidence should have been conclusive, but, as is so often the case with subjective personal testimony, it was not to be.

Later in the book we'll examine some wider implications of these phenomena. We may be amazed how many awesome possibilities the simple example of a sphere passing through a plane throws up as we delve into the whole subject of – to use Abbott's term – Dimensionality.

The loss from our own human experience of that one single dimension of height would render our world utterly different. Throughout the universe, all three dimensions work together in concert, and the loss of any one of the three would collapse the whole system.

This sense of co-operation between separate dimensions is reminiscent of many other aspects of our life such as family relationships and working environments, inter-dependence among humans, animals, birds, fish, insects and even plants. We also see it in inanimate things: consider the contrast between the destructive power of a supernova, and the gathering, shepherding effect of gravitation as it unassumingly holds our universe together and keeps our feet on the ground. In short, this balance between the ideas of

unity and separateness runs through the whole batch – with our telescopes we see it in the heavens, we know about it in the atoms and molecules that separately and together make up our world, and even the God of the Bible is said to be a Trinity (tri-unity: three 'persons' mysteriously united in one).

Indeed, our whole world is made up of 'nested hierarchies' in which the whole is somehow greater than the sum of the parts. We shall be looking into their role as the book progresses.

To the Point

Finally, *A Square* and *Sphere* continue on their merry way down to Pointland, a land of zero-Dimensionality, 0D, possessing neither length, width nor height… just a singularity! For the purposes of Dr Abbott's book this is one single theoretical point of no dimensions at all, which exists as a 0D being who not only occupies the entire world but *is* the entire world! As I write this I'm throwing around thoughts of how similar this chap seems to God… e.g. he has no physical dimensions, he is unique, nothing else exists in non-Dimensionality but him, and he is extremely pleased with himself.

But there's a problem... *Point* is completely oblivious to the existence of anyone or anything but himself. Hardly omniscient then, nor omnipresent, and certainly not omnipotent! Just zero, as his dimension suggests. *Sphere* explains to *Square* that he cannot enter *Point's* world to make himself known, as *Point* <u>*is*</u> his world. *Point* could hear him – as could all the rest – but having no concept of anything outside himself he paid no heed, but it matters little, because the whole idea that it was possible for them all to have consciousness was invented for the purposes of the story anyway.

Throughout Abbott's book, *A Square's* little catch-phrase is *"Upward, not Northward."* This he chants as a mantra/mnemonic in the ongoing fight to keep the dwindling mental flame of his higher dimensional vision alive. Unhappily the phrase ends up haunting him in his latter days *"like a soul-devouring Sphinx"*. All those among whom *Square* lives are hardened to terminal bigotry in relation to the concept of other dimensions, and sadly he finishes up persecuted by his peers and given life imprisonment for what they perceive as his ridiculous and subversive beliefs.

The vision itself of Spaceland – the 3-Dimensional world – was crystal clear at the time he experienced it, but he simply couldn't retain it in the forefront of his conscious mind when restored again to the Flatland constraints of his native 2D. His problem was the sheer impossibility of imagining a third dimension of height in a flat universe, and he simply couldn't find a way to conceive of or express it, even to himself, rendering the task of communicating it to others virtually (or as it turned out in the book, actually) impossible. Nonetheless, with great integrity *A Square* keeps the faith to the last, a true martyr, finally closing with the sanguine hope that...

> *"these memoirs, in some manner, I know not how, may find their way to the minds of humanity in Some Dimension, and may stir up a race of rebels who shall refuse to be confined to limited Dimensionality."*

May we be those rebels!!