

Chapter 11

The Magic Treadmill of Time

If we are to permit the possibility that the 3rd Dimension proper is as different from the 2nd as the 2nd is from the 1st – as we will shortly – then we might well conclude that the character of time as the 4th Dimension is also intrinsically different. In such a scenario *every* dimension should bear its own distinctive stamp. However, this is not the same thing as our present spatial/temporal distinction; because whilst a description of each dimension as intrinsically different aspires to an understanding of what dimensions *are*, the spatial/temporal distinction may simply be a description of how they *appear*, which, as *Flatland* extrapolation demonstrates, is viewpoint-dependent.

In *Flatland* terms, the 4th Dimension is not distinct and special, it is merely the fourth in a configuration that ascends in complexity, building itself into the nested hierarchy in such a way that each succeeding dimensional layer is composed of the close stacking of the last. There is nothing in the logic of Dimensionality to suggest that the 4th Dimension is in any way, as *Wikipedia* puts it, ‘*of a different sort from the spatial dimensions*’. Certainly we *perceive* time to behave differently, but is it *actually* behaving differently? It may behave differently from length, width and height but, as we have seen, these are not necessarily descriptions of what the lower dimensions *are*, merely quantities – or concepts – by which they may be represented.

Simple Minds

It is my belief that, having elevated our viewpoint-based experience of temporality within our universe to the status of objective science, we are simply confusing ourselves. *Flatland* principles do not discriminate between dimensions, rendering the theory behind the structure fairly simple – and simplicity can be a very good thing. Janna Levin tells us that,

‘There is a campaign for simplicity in fundamental science. The simpler the better.’^a

We are looking at foundational principles here and I believe we are safe enough to allow Ockham of old to get his razor out. Certainly Einstein appeared to think so when he said,

‘I have deep faith that the principle of the universe will be beautiful and simple.’

Dimensionality may or may not be *the* principle of the universe, but it does describe a very beautiful and analogously accurate framework with a lot of explanatory power. As we have seen, time is the problem child of physics and continues to defy all efforts at restraint, with respected physicists such as Lee Smolin even resorting to philosophy in an effort to find an inroad into the dilemma. In his book *Time Reborn* he asks a critical scientific question (which to most folks probably sounds crazy): ‘*Is time real or not?*’ He ventures,

‘This is why it matters for each of us whether time is real or not: The answer can change how we view our situation as seekers of happiness and meaning in a largely unknown universe.’^b

By looking very closely at how the Flatlander would have experienced his world, we are about to break down the twin phenomena of space and time. We will see that there’s a dimensional sense in which

^a Janna Levin, *How the Universe Got Its Spots*, Phoenix 2003, P179

^b Lee Smolin, *Time Reborn*, Houghton Mifflin Harcourt 2013

time *is* real, and also a sense in which it is *not*, because all dimensions obey the *Principle of Relationship*^a, however they might be numbered.

Goldilocks *or* the Four Bears

Historically, EA Abbott's *pièce de résistance* has been hailed as a masterpiece of geometrical insight and mathematicians have claimed it as their own, but if *Flatland* teaches us anything at all it is the importance of viewpoint. Dimensionality teaches us that viewpoint – how things appear from where one stands – may be the key to understanding our place in the grand scheme of things. Much to *A Square's* befuddlement, *Sphere* informed him of something about his flat world of which he was blissfully unaware: “...*what you call Space is really nothing but a great Plane.*” However, as we have just seen, *Square's* physical experience of his world was 1-Dimensional – the circle around him – so what he called space was actually a line. How then could it be a great plane?

Clearly he *lives* on a plane (no-one is disputing that Flatland is flat) but he does not *see* a plane because he exists level with the plane and views it edge-on in keeping with the ‘*Edge-On*’ Principle^b. The key here is to remember that EA Abbott lived in a pre-Einsteinian age, an age in which the practical relationship between space and time was not very well understood. The ‘great Plane’ upon which *A Square* lives is his entire universe, and – in keeping with our earlier discussion – *Square* would actually experience his great Plane as a 2D space-time.

Therefore:

- Space, for *Square*, is the bit he sees: it is his edge-on view: a 1D circle.
- Time, for *Square*, is his 2nd Dimension, and it extends away from him all around.

Since ‘*relativity's mathematics works fine in any number of dimensions*’^c, we find that our Flatlander inhabits a 2D space-time^d.

Time in 2D

A Square looks all around him and watches his world change because he finds himself moving across it. But to him all he is doing is changing the compass direction in which he is facing. Even so, as he does so his world changes. Why? Because he is also moving through his 2nd Dimension which, in his space-time, is his last dimension and as such ‘behaves temporally’ – but, *what does this actually mean?*

His 2nd Dimension is the means by which his world experiences change, continuously revealing to him a ‘new’ bit of 1D, and although from his perspective he cannot see the process in action, the 1D world around him changes. His 2nd Dimension acts the ‘record keeper’, recording all the relative positions of everything in his world. These positions as he views them exist in static snapshot, but change relative to one another with each changing snapshot so that – just as it is for us – his last dimension acts as his *means of change*. This ‘sequence of snapshots’ is similar to the scenario described by philosopher Craig Callender of UC San Diego who writes that time in this sense ‘*becomes redundant. Change can be described without it*’.^e

^a *The Principle of Relationship*: Whatever is true of the relationship between two adjacent dimensions is true of the relationship between any two adjacent dimensions.

^b *The 'Edge-On' Principle*: Each dimension is viewed from within itself one dimension lower.

^c New Scientist, *Seeing Triple*, Matthew Chalmers, 28th Sept 2013

^d Which *Sphere* views spatially as a great plane because he inhabits a 3D space-time.

^e *Scientific American*, A Matter of Time, *Is Time an Illusion?*, Craig Callender

But without his last dimension, wherever the Flatlander turned, everything on his circle would remain the same, frozen in one place.

But, we might ask, if he can't see his 2nd Dimension, how does he move through it?

Although the Flatlander can spin on the spot, moving around his 1D circle, we must accept that our Flatlander *does not have the power to move at all into his 2nd Dimension*. At this point the original *Flatland* allegory becomes misleading, because *A Square* would not have freedom to move around the flatness of his world and we must now clear our minds of this misconception. In a 2D space-time he is rooted to the spot, and instead *his world moves beneath him*. Like a gigantic, rolling treadmill it trundles along completely independently of *A Square*. The effect this has is to alter the look of the world around him as his landscape moves inexorably forward. In this way his second degree of freedom acts as the means of change – the temporal dimension – within his world, modifying the characteristics and appearance of everything he sees on his 1D line.

Although it is the world that trundles by him and he has no influence over the rate at which it trundles, the Flatlander still retains the power to spin round, to choose his direction, thus exerting a measure of choice over his own fate. Indeed he possesses complete freewill in his 1D 'spatial' direction, because he may turn a full 360° at any speed he can muster. It's just the trundling rate of change into his 2nd Dimension that he can't control, but it is essential that it be this way or his world would be jammed in one position like a 1D freeze-frame.

What all this means is that *A Square* lives within a 2D space-time, which in co-ordinate terms may be written (x,t) . His last co-ordinate, his second degree of freedom, is invisible to him and acts as time. It is his temporal dimension. *So why is it invisible?* It is invisible because, any direction he looks, it points perpendicularly away from him and he views it point-on as the direction in which he is travelling, just like viewing a pencil or a needle point-on. And since a point is 0-Dimensional, he sees nothing. It points radially away from him as though *A Square* were always at the hub of a spoked cartwheel, with himself continuously located at the centre. From this we can see that the Flatlander's experience of the world is 'observer-centric'^a.

So, considered in terms of Flatland's 2D space-time, the radial nature of the last dimension answers our first question about time, *explaining why the Flatlander's time direction is invisible*. Now we just need to figure out why it acts in one direction...

The Bubbling Forth

All this begs the question... *'How can a rolling treadmill act radially?'*

The treadmill analogy is limited. We must imagine that instead of standing on a rolling treadmill which acts only in one direction, the Flatlander is on a 'magic' treadmill that acts *in every direction* around him, as though he were standing on a vent and the ground is constantly bubbling up from beneath his feet like lava, or wet cement. As it bubbles forth it spreads out radially and flat in all compass directions in an ever-widening disk, but, as observer, he never gets carried away with it because he is always located at the centre of his own personal, observer-centric space-time location.

^a Observer-centricity will become more significant as we go on to look at the shape and properties of the observable universe.

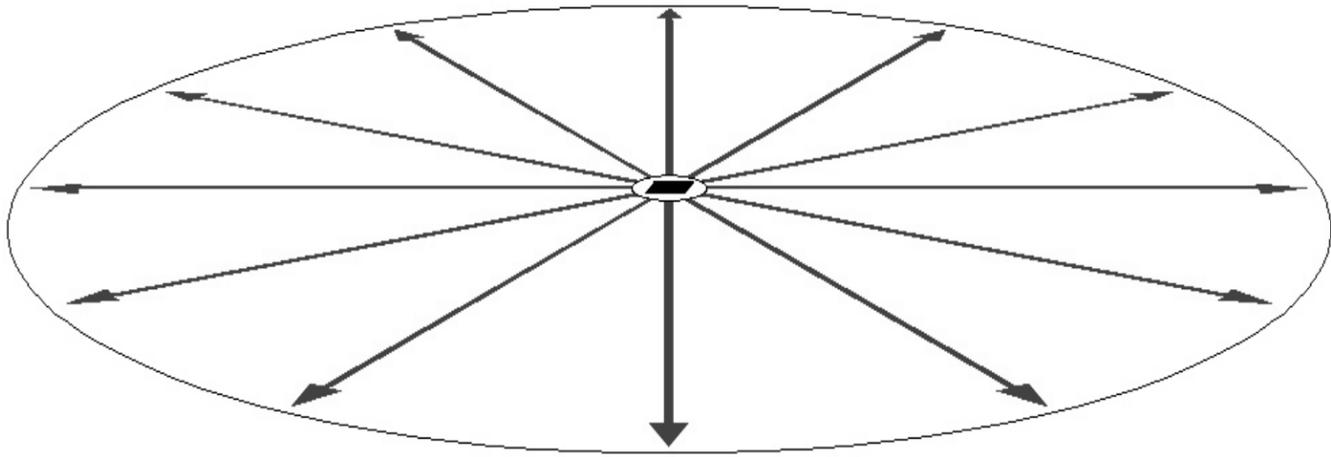


Fig.1 The Magic Treadmill in a 2D space-time. The Flatlander exists at the centre of a ‘spoked cartwheel’. He is hemmed in by a 1D circle – his moment now – which is jammed up against (i.e. integrated into) his perception. His 2nd Dimension ‘bubbles up like lava’ from his observer-location and heads away from him, expanding his space-time into a 2D disk comprising his ‘block universe’. His 2nd (i.e. his last, or temporal) Dimension always points away from him, therefore he always views it ‘point-on’ like a needle pointing away from him in every direction. A point is 0D, therefore his 2nd Dimension remains forever invisible to him.

Reflection... Note that the invisibility of the Flatlander’s temporal dimension is the result of his viewpoint, and is not intrinsic to the 2nd Dimension. It will appear flat to anyone able to view it from above. Thus a *Flatland*-based dimensional structure shows time to obey the same consistent principles as space.

Furthermore, because the Flatlander only senses in 1D (and this is important) not only can he not get swept away from the centre with it, but *he cannot physically see the ever-widening patterns spreading out around him* because, like ripples on a millpond, they are receding into his past. For Flatlander, his present, his moment 'now', consists entirely of the 1-Dimensional circle which rings him in at zero distance. For him space is 1D, and it is jammed right up against his perception.

His spreading 2D 'means of change' has 'measured' all the change it is going to, and, immediately upon receding from his 1D perception-ring, has instantly set like cement. It has turned into an unalterable yet ever-receding 2-Dimensional ‘disk-shaped’ storage facility for all the events that happened on his 1D circle, but are no longer happening.

Each fixed circle that started out as his 1D ‘moment now’ stacks as a widening 1D circular cross-section into the 2D disc. As it recedes, each ‘former now experience’ expands steadily (as the analogy suggests) so that not only does it get farther away in time but more stretched and thinned out, like ripples on a pond, although the information the ripples encode can never change.

Please note however that *A Square’s* actual past does not consist in *everything* on the widening disk – because the whole disk is the history of ‘everything from his viewpoint’ – but only those points on each circular ripple which represent the direction he was facing at that time, which may be traced somewhat like a squiggly scratch on an old vinyl LP.

This is the Flatlander’s world-line through his 2D space-time.

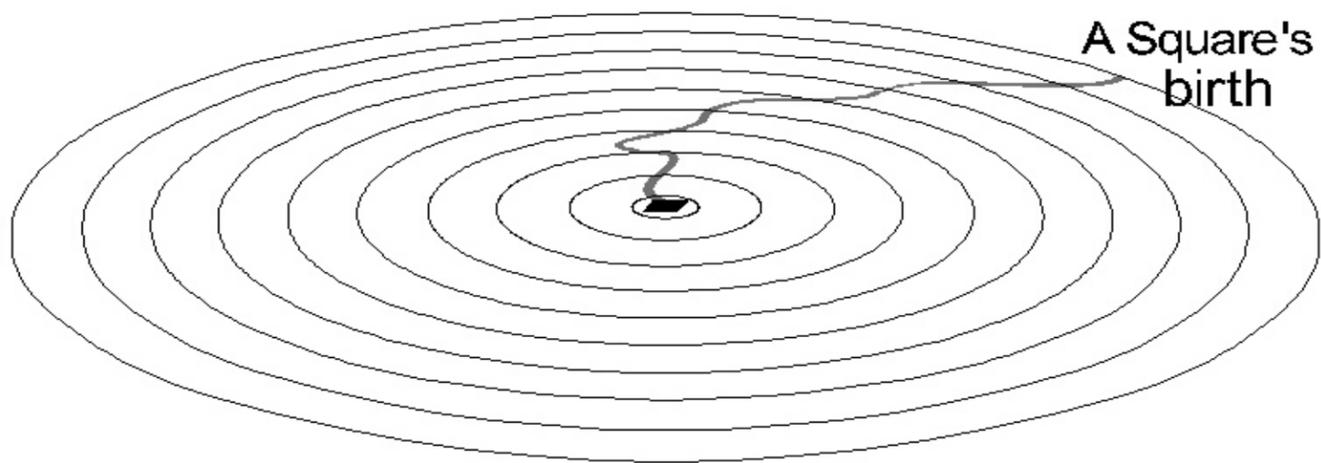


Fig.2 The Flatlander is located at the centre of his universe experience. As he turns on the spot to look around, his 2nd Dimension emanates from his unique observer-location, rippling away from him, presenting him with a constantly refreshed 1D view of the present on his encompassing circle.

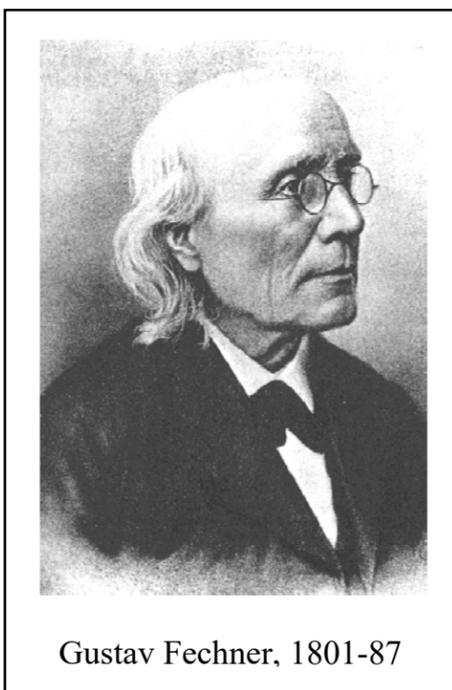
The squiggly line represents his life, his 'world-line' through his 2D 'block universe' on which is set his past – forever unalterably out of reach, and consisting of all the directions on his 1D circle he has previously faced.

Reflection... This means that the Flatlander's origin is fixed forever on the outer rim of his ever-expanding past – at the 'beginning of track 1 on his LP'. This is similar to how the origin of our universe is always located on the expanding outer surface of our observable universe. This is not a coincidence, but evidence of the consistent nature of the dimensional structure. In Section 5 we will investigate this connection.

So now we have gained a grasp of how the 2D dweller experiences space and time by the simple expedient of reducing the number of dimensions to a manageable (but theoretical) two; let us now add one more dimension and picture what would happen in a 3D space-time (very briefly because this world is also theoretical). We will then apply one more dimension which will bring us up to the 4D space-time in which we live and groove and have our being.

It's all getting rather exciting! Let's apply the *Principle of Relationship*^a...

Time in 3D



EA Abbott was not the first to ponder the implications of Dimensionality. Consider Plato's celebrated shadow men (a kind of *Flintstones* meets *The Matrix*) who, before they escaped, spent their lives sitting in a row tied to chairs in a cave whilst a fire glowed behind them, blissfully unaware that their flickering shadows on the wall were not the sum total of their lives.

Later, in the writings of pioneering German psychologist Gustav Fechner we hear echoes of Plato. However, in Fechner's world the shadows *are* the men.

Tom Banchoff writes,
'The first person to develop the dimensional analogy in the 19th century was the psychologist and physiologist Gustav Fechner in Leipzig. He wrote a

^a *The Principle of Relationship*: Whatever is true of the relationship between two adjacent dimensions is true of the relationship between *any* two adjacent dimensions.

small story, Space has Four Dimensions, as part of his collection Vier Paradoxe published in 1846 under the pseudonym of Dr. Mises. Fechner's two-dimensional creature was a shadow man projected to a vertical screen by an opaque projector. He could interact with other shadows, but, based on his limited experience, he could not conceive of a direction perpendicular to his screen.'^a

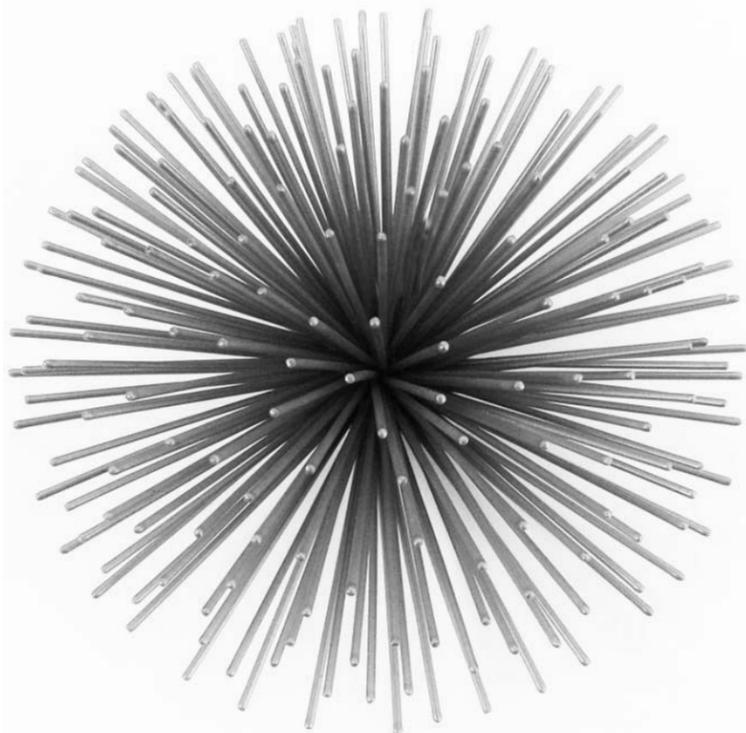
At first glance the shadow men's experience appears similar to Flatland, but Fechner is describing a 3-Dimensional space-time (Spaceland) in which the protagonist is able to physically experience length and width. Banchoff continues,

'Fechner suggests that for such a being, time would be a third dimension, expressing the movement of his whole screen in a direction which he cannot comprehend spatially.'^b

Remembering that the Flatlander's 1D circle is jammed up against – i.e. integrated into – his sensory perception, we must somehow picture the same for the Spacelander, one dimension up. But how? Recapping from Chapter 9, with *Sphere* as our representative of Spaceland:

Sphere discerns the 3-Dimensionality of his world by feeling the hypothetical 2-Dimensional surface of 'flat things' all around him. *Sphere's* reach into his world is always from the zenith down onto the flat surface before him which forms his spherical boundary – in other words, from the centre out... But perhaps the most important thing to get our heads around is the idea that his spherical environment exists at zero distance from him, shrink-wrapped. His whole world is 'jammed up against his perception'.

The Spacelander – who inhabits a 3D space-time in which, as Fechner observes, *'for such a being, time would be a third dimension'* – experiences his two spatial dimensions of length and width as flatness at zero distance, jammed against his perception as though he has been vacuum-packed by its enfolding surface. He indwells the 2D surface of a sphere. These two dimensions, for him, constitute space.



His third dimension of depth is always – as Fechner observes – *perpendicular* to his experience. It extends radially away from him *in every direction* as though he were at the centre of a spiky ball or the fluffy head of a dandelion. This is the 3-Dimensional analogue of the Flatlander's 2D 'cartwheel', and in the same way his last dimension – acting as his means of change – remains physically invisible to him because, no matter which direction he faces, he views it point-on, in 0D.

He is experiencing the stacking of his 2D world into his 3rd Dimension by the same 'magic treadmill' principle described above, except the Spacelander's treadmill is not 2D, but 3D – instead of flowing out from him to radiate flat like spokes of a cartwheel, it radiates in every direction just as light rays radiate from the sun. And instead of ripples, his 2D world flows out onion skin-style to solidify into his 3D past, like the spherical shockwaves of a supernova.

His space-time is (what we would experience as) a sphere.

^a <http://www.math.brown.edu/~banchoff/gc/ISR/ISR.html> - Accessed 19th March 2016

^b Ibid. - Accessed 16th Oct 2016

Time in 4D

Because *Flatland* geometry is dimensionally accurate, all these same principles are at work within our own real 4D space-time, in which *our* last dimension acts as the means of change.

Again by applying the *Principle of Relationship*^a, our 4th Dimension points geometrically ‘away’ from us and as a result, we see nothing, which is why the 4th Dimension gives us the impression that it is ‘non-spatial’. For us this pointing away takes place in a fourth direction rather than a third or second as in Spaceland or Flatland, but this makes no difference to the principle. Time, although genuinely our 4th Dimension, is *viewed by us point-on as a 0-Dimensional point*, spraying radially away from each and every observer-location in the universe in the same way as light radiates from the sun.

From the viewpoint of the individual this 4th Dimension is thereby rendered invisible, whilst we constantly observe the lower three dimensions changing form.

The Block Thickens

Crucially (remembering from a little back) this radial direction is *not depth*. Do not be deceived by depth. The 3-Dimensionality of our world exists at zero distance from us. It may seem strange to think of 3D in this way, but we are totally immersed within it, our bodies are made from it, and it is jammed up against our sensory perception in precisely the same way as the Flatlander’s 1D circle and the Spacelander’s 2D vacuum pack.

This all-new fourth direction we experience as *3-Dimensional change*. We feel as though we are moving into all-new 3D scenarios as it springs continuously from each and every space-time point-event^b in the whole of the universe so far. For us, our magic treadmill extends radially into a 4th Dimension. Each one of us stands over a ‘4D vent’ with 3D jammed against our perception. Our means of change bubbles forth into the moment now, concreting itself instantaneously into our past in a direction which we cannot see physically. And there it remains, set firm into the block universe like 4D ripples in a 4D pond, fused forever into a permanent record of the events in which it consists as the 3rd Dimension stacks into the 4th, and receding farther and farther into what we, from our geometrical viewpoint, call the past.

‘But if I cannot see it because I am always at the centre, why can't others see it around me, or I them?’ In a sense it is wrong to think of ourselves as not seeing it. Although we don't see it from a physical perspective, we see it all the time in our mind's eye^c, because we are always conscious of time's passing for ourselves and for everyone and everything else. However, the reason we don't *physically* see it pointing away from ourselves or someone else is because the 3-Dimensionality of the world is infused throughout the brain and nervous system (integrated into our perception at zero distance), and it is 3D alone – which we call ‘spatial’ – that makes up the physical world.

^a *The Principle of Relationship*: Whatever is true of the relationship between two adjacent dimensions is true of the relationship between *any* two adjacent dimensions.

^b A space-time event is a unique theoretical co-ordinate location anywhere in the universe at any time, denoted (x,y,z,t) . Although this is not strictly speaking a ‘point’, I will use the philosopher Hans Reichenbach’s handy term ‘point-event’ as we go because it is easier on the brain!

^c There may be a clue here to the dimensional nature of memory and consciousness, which we will investigate as we go.

Reflection... Although the law of cause and effect is never violated, Einstein's Relativity shows that not every point in the universe experiences time's 'moment now' simultaneously. Reduced to an analogical 2D space-time we might think of this as: the faster the Flatlander spins in 1D, the slower 2D flows out from his point-event, because they are linked variables. He possesses a total of two directions in which he may – so to speak – move, but their combination must always relate to a 'total' maximum constant. Similarly, we possess four directions with the same combined limitation as described by Special Relativity. In our reality this constant is 'c', the speed of light.

Summing up... every space-time event in the universe – past and future – is at the centre of its own 4D 'dandelion head', from which the radially expanding 'magic treadmill of time' projects away into a 4th Dimension. Like the Flatlander we do not see this extra direction. Because a point is 0-Dimensional the Flatlander views his last dimension point-on, and in precisely the same way we view our last dimension 'point-on', *thus answering in terms of Flatland geometry the philosophical question of the invisibility of time.*

Setting it out more formally:

The Magic Treadmill Principle:

Time, as the n th Dimension in an n Dimensional space-time, issues forth perpendicularly and radially from within the frame of reference of each space-time event. To the observer this n th Dimension appears 0-Dimensional (is viewed 'point-on') and is therefore invisible, but results in $(n-1)$ Dimensional change, and stacking of the $(n-1)$ D surface into the n th Dimension, taking the form of the past.

This is a description of time from the observer's viewpoint. Throughout the n D space-time itself (i.e. an n Dimensional universe) this process continues from its origin at a singularity to its completion at a singularity^a one dimension higher, between which it forms the whole n th Dimension. Were we somehow able to view the n D universe from outwith the dimensional structure we would see that it is technically not a dynamic entity, but static. Its dynamic 'flow' is our $(n-1)$ D view^b of the stacking process in action.

Reflection... The magic treadmill takes place as a continuous 'outpouring of more universe' from each and every space-time event. Each of these new and existent point-events constitutes an observer at the centre of the observable universe. In this way the observer, located at any point-event, is the centre of a 3D spherical cross-section of the 4D hyperspherical universe, (the considerable implications of which we shall consider shortly).

In principle the magic treadmill resembles the steady state universe of Hoyle, Bondi and Gold wherein matter emerged continuously at every point throughout space. Although they were wrong about the continuous creation of the 3rd Dimension they may, in principle, have been on track for the 4th. Had they been able to stand back in dimensional terms from their perfectly understandable preoccupation as scientists with physicality, they might have realised this.

^a Here a singularity represents a dimensional ambiguity similar to the phase change between ice and water wherein a dimension transitions from its form as completed n D to its new role as the first stacking cross-section of $(n+1)$ D. We will examine this phenomenon in Section 6 in terms of its potentially real implications for the Big Bang.

^b *The 'Edge-On' Principle:* Each dimension is viewed from within itself one dimension lower.

The Arrow of Time

In his book *Time's Arrow and Archimedes' Point*^a, Australian philosopher Huw Price asks, 'But what would a properly atemporal metaphysics be like?' In dimensional terms an equivalent question might be, 'What does the 4th Dimension **actually** look like?'

Our *Flatland*-derived dimensional structure can never render space-time atemporal because, as extrapolation shows, the *n*th Dimension as experienced within an *n*D space-time must always be temporal. However, theoretically at least, the metaphysics of Price's conception of a 4D 'block universe' could be viewed atemporally from a 5th Dimension (or higher), thus eliminating the way that *we* experience time, because stacking of the 3rd Dimension into the 4th would be complete. Sadly Professor Price would then find himself asking exactly the same question of a 5D space-time (and so on...)

Which brings us to our second question: time's unidirectionality. Let us remind ourselves of the *Principle of Stacking*:

Each dimension is composed of an indefinitely high number of cross-sections (slices) of the dimension below, stacked together and fused into a single entity.

This geometrical principle, foundational to *Flatland*, does not simply describe a final state, but a process. The relationship of stacking to the whole dimensional structure is dynamic and there is nothing in all creation that is not the result of its influence. Stacking into time results in each point-event^b taking up a unique co-ordinate position in all four dimensions (*x,y,z,t*). In practice, the capricious nature of this constant change may have significance at a quantum level, but what is happening dimensionally is that 3D slices (cross-sections) of the 4th Dimension stack up 'one by one' to mould the character of the next dimension.

Stacking is of necessity a one-way process – a movement from nothing to something. It moves from beginnings through to endings. So, of course, does entropy – the tendency of systems to seek the lowest possible energy state. However, the difference between the two would appear to be profound, even opposite, and whilst Newton's Second Law of Thermodynamics^c is clearly at work in the universe and time's unidirectionality is often attributed to it, the Second Law could be more of a symptom than a cause. Should the dimensional structure prove accurate, it is my belief that stacking may be the more fundamental because it is *creative*^d and, rather than 'dismantling' as per entropy, it drives (or pulls) to completion all the nested hierarchies in which everything consists, as each dimension in turn assumes its own new nature^e.

So, Dimensionality describes the *direction* of the arrow of time, but it cannot explain the *existence* of the arrow of time any more than it can explain the existence of anything. Instead what it does is to replace this queen of mysteries with another, perhaps even greater mystery: the *a priori* acceptance of stacking as fundamental, of which time's arrow may simply be, in terms of the overall dimensional structure, a special case.

^a Huw Price, *Time's Arrow and Archimedes' Point*, Oxford University Press 1996, P266

^b We may conveniently think of these as uniquely discrete points, 'space-time events', in the block universe, perhaps related to the Planck quantities, although in reality the dimensional structure is unlikely to possess points as such.

^c Oxford Dictionary: 'the Second Law of Thermodynamics says that entropy always increases with time'.

<https://en.oxforddictionaries.com/definition/entropy> - Accessed 16th Oct 2016

^d The idea of 'creativity' as a fundamental of reality may not go down a storm in physics. However, I suggest it here because I confidently believe – as Tegmark has observed – that physics exists as an attempt to describe reality, not to dictate it.

^e *The Principle of Character*: Once the stacking of a dimension is complete it assumes a whole new character. Its individual cross-sections fuse together and their discrete nature becomes indiscernible.

Reflection... Time's arrow is a special case of stacking because stacking applies between *all* dimensions; the arrow of time reveals the action of stacking only between the 3rd and 4th Dimensions.

Going Through Changes

In terms of Einstein's '*four-dimensional continuum*'^a and science's block universe, although it *feels* as though it is me who is moving steadily through time, there is a sense in which I am actually at rest in a completed 4th Dimension like an elongated man-shaped worm, at one end of which I am a baby and the other end a corpse. In that sense the dynamic I call my life does not primarily consist in such trivia as movement – through time or otherwise – but in the process of stacking. From my current viewpoint, this occurs as a stream of 3D cross-sections of an invisible 4th Dimension, stacking up in a direction which bubbles up through me and every other point-event, and radiates away into a new and invisible direction, where – as surely as I exist now – I exist in my past and 'will' in my future.

My apologies if I labour this somewhat, but it's important for us to get our heads around the magic treadmill mechanism as it describes the way in which the 4th Dimension emanates from every point-event in space to form the receding past^b, because it renders all dimensions consistent in their obedience to the principles of EA Abbott's *Flatland*. As such it will crop up as we progress.

Reflection... It's also worth noting that a point-event and an observer location are the same thing, although *conscious* observers are obviously not located everywhere – but what this demonstrates is that the unfolding of the universe itself is observer-centric. As we ascend the structure in chapters to come, we shall see that observer-centricity is critical to the model.

In the meantime, as per the Flatlander's spin – i.e. his freedom to choose which direction to face – I am free to decide, by deploying my physical senses, in which combination of three directions to face before the 4D lava sets. I may decide the shape of my worm, and you may decide yours.

But as for its length...

^a Albert Einstein, *Relativity, Appendix 5*, Routledge 2001

^b The world-line of a point-event, and the world-braid of all point-events.