Chapter 20

The Space-Dent

Einstein told us that gravity is not a force. It constitutes the movement of mass-energy and light along paths of least resistance, paths which may appear curved – even elliptical – to us who view them one dimension lower[a] in 3D, but which are actually straight when reckoned in terms of the four dimensions of space-time. And physicists tell us these paths are shaped as though ordinary space itself were 'curved'.

Is there a way for us to imagine this?

Think of a lettuce leaf, and imagine your schoolteacher has set you the task of flattening it out, say to make a pressing between the pages of a book (this is the stuff of nightmares because you are going to get into trouble whatever happens!) – a lettuce leaf is all 'frilled up' and it is obviously not possible to flatten it out.

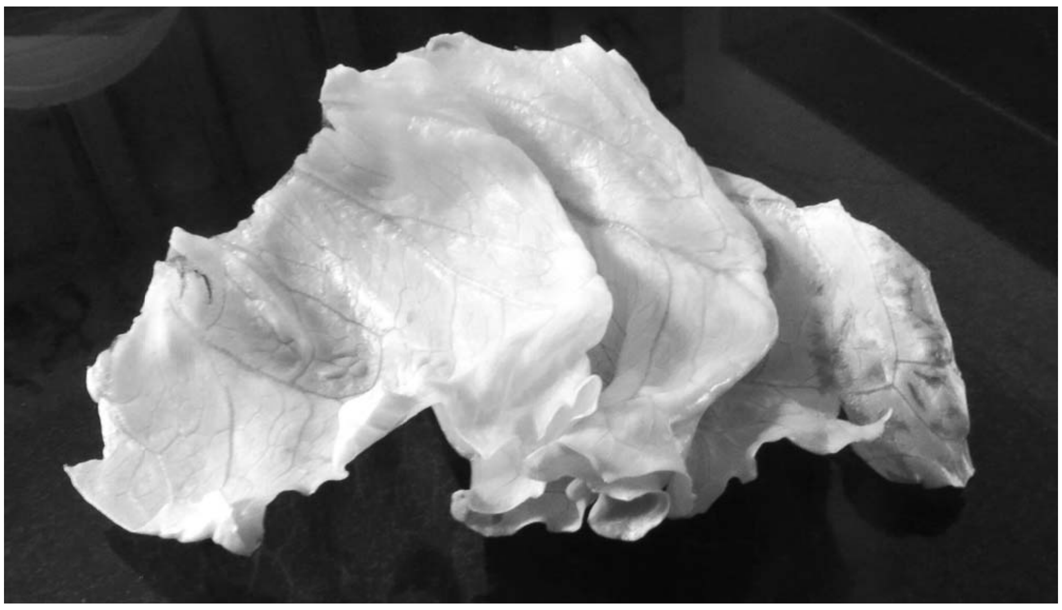

Fig.1 The lettuce leaf is ruffled into folds and frilly edges, which is most clearly viewed edge-on.

Now, imagine you lay the leaf on a sheet of paper, look down from above and draw a simple outline round its shape on the paper, cutting it out.

Now you have *two shapes the same*, one of which is frilly and the other is flat. Both are 2D, but the frilly leaf's 2D surface has more area than the flat leaf. How does it achieve this? It does it by simply extending into and 'borrowing' extra 2D from all the 3D space around it (and in the process becoming non-Euclidean).

Now we extrapolate – imagine all that kicked up by one dimension. All we have to do is replace 2D area with 3D volume. The lettuce leaf is now a planet which somehow occupies more 3D space than is available to it, which it 'borrows' in exactly the same way from the 4th Dimension around it. Applying the analogy (the only way to picture higher dimensions) the basic idea of this is not really complicated.

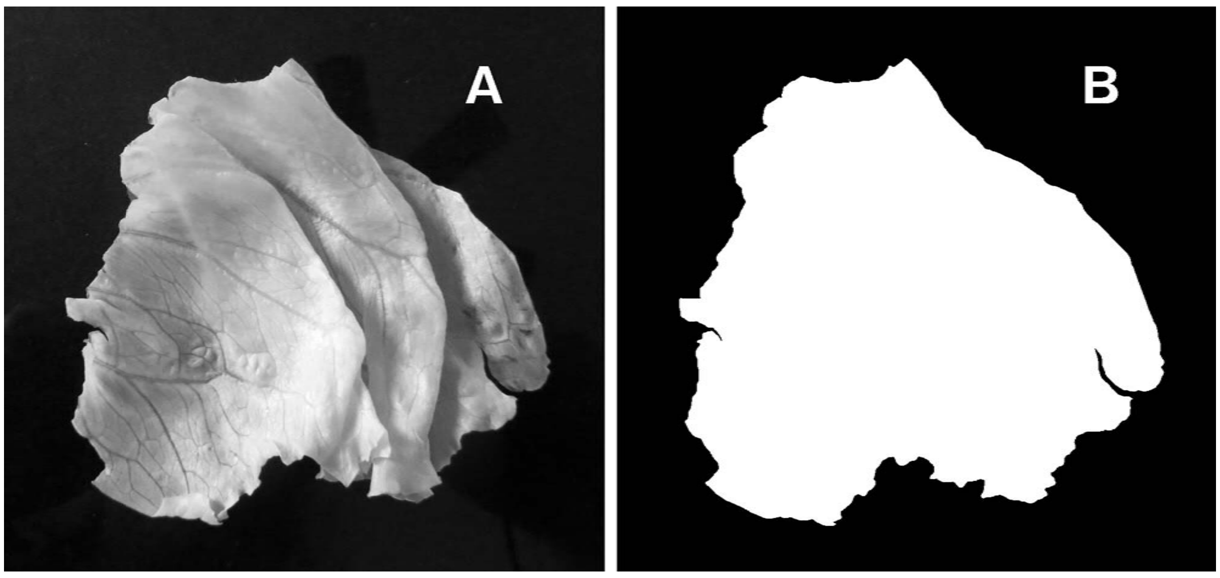

Fig.2 Viewed from above, we see the outline of the lettuce leaf's shape. However, the surface area of the leaf itself is clearly greater than that enclosed by its outline.

Although the mathematicians might tell us this is an over-simplification

[a] *The 'Edge-On' Principle:* Each dimension is viewed from within itself one dimension lower.

(because the maths is more complicated) it describes very well Einstein's underlying principle of gravity as curvature: the planet possesses 'extra 3D', which is essentially 'extra space', or an increased density of space. We will call this the 'lettuce effect'. (Time is involved but we'll come to that.)

Now let's illustrate the gravitational scenario in more familiar terms, using the bowling ball/rubber sheet analogy which has become standard fare in the visualisation of gravity.

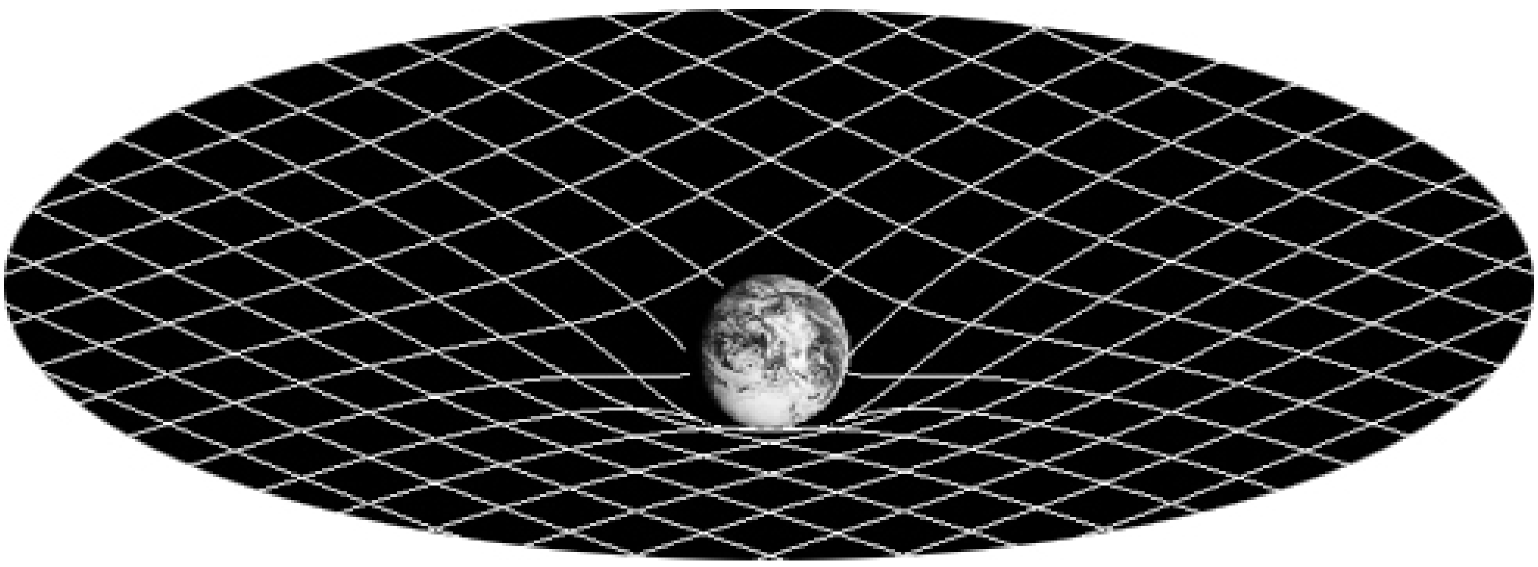

Fig.3 The bowling ball/planet/rubber sheet analogy, illustrating in 2/3 Dimensions the curvature of space-time due to mass.

Before we continue, some points:

1) ***It's imperfect:*** Physicists are unhappy with the rubber sheet analogy because it has limitations, one of which is that it requires the natural gravity of the Earth to physically work. However the rubber sheet, representing space-time, is still useful for imagining curvature due to mass, but space itself is not under any form of 'rubberised' tension.
2) ***A warped view:*** Because we cannot visualise it, the mathematical term 'curvature' was derived from a 2D (flat) analogy because mass behaves in 3/4-Dimensions *in a similar way* to curvature in 2/3-Dimensions. Consequently, funky 'sound-byte' flatness-based descriptions offer a very limited insight into what is actually going on which, it is said, may only be grasped through the maths. When physicists talk about the 'bending' and 'warping' of the 'fabric' of space-time they are using the shifted down language of a 2D 'lettuce leaf-style' analogy so that we can picture it. More on this shortly.
3) ***Rock and roll:*** The presence of the bowling ball (or the cool-looking TV planet graphic) to represent mass, although visually helpful in one sense, is extremely misleading in another. Why? Because it is *the dent itself* which is important to the analogy because it represents the deformed shape of space-time. Although the mass generates the deformation, it then responds to the deformation's shape (and deformations caused by other masses) as it moves.
4) ***Asteroids:*** Space-time just *behaves* as though it has a ball on it, with rolling as an analogy for friction-free movement – to illustrate this point, the mass of a rough-hewn asteroid would act the same, and it certainly wouldn't roll on a sheet!

The dimensional structure is surprisingly comfortable with gravitation. Why should it not be? After, all, gravitation is the product of a dimensional interaction. With this in mind I will now attempt to describe this interaction in terms of our *Flatland*-based concepts of stacking and cross-sections. For all its limitations, the rubber sheet remains a good 2D analogy of the action of curvature because it illustrates the same principle as the lettuce leaf.

Let's now describe curvature within the analogy, extrapolate, then compare dimensionally parallel statements. We'll start by doing the same to the rubber sheet as we did to the lettuce leaf…

Curvature, in 2/3D:

- When, due to an object's mass, the 2D dent dips into the 3D space around it, it 'borrows' from 3D so that its area increases. If we draw a circle to mark a perimeter[a], the area within the circle is greater for the 2D dent than it would be if the mass were not there and it were flat.

In the analogy, mass causes the flat rubber sheet to 'dip down' into a gravity well in the 3D of surrounding space, in the process increasing its 2D area by the exact same mechanism as the lettuce leaf. Here is how Emeritus Professor of Physics at the Open University, Russell Stannard expresses this concept,

> *'In the illustration we can then represent the three-dimensional space by this two-dimensional slice, and use the illustration's third dimension to accommodate the 'bending'.* [b]

Now, repeating the same statement, let's extrapolate, kicking it all up by a dimension…

Curvature, in 3/4D:

- When, due to an object's mass, the 3D space-dent extends into the 4D universe around it, it 'borrows' from 4D so that its volume (rather than area) increases. If we form a sphere (rather than a circle) to mark a perimeter[c], the volume within the sphere is greater for the 3D space containing the mass than it would be if (the mass were not there and) it were ordinary space.

So we see that the presence of mass-energy may be thought of as a 3-Dimensional 'space-dent' which – because it applies to length, width *and* height – increases in volume rather than area. By dipping into and borrowing 3D from the surrounding 4D, it is the 4th Dimension[d] that accommodates this increase in 3-Dimensional volume.

Now I'm Here

At this point we bump up against time's difference from the other three dimensions of space, and many physicists are understandably reluctant to commit to such a direct extrapolation because of the difference between the way we experience time[e] compared to the three spatial dimensions. In *Flatland* terms this difference is explained as a quirk of our viewpoint due to our position within the dimensional structure, and because the consistency of the *Magic Treadmill Principle*[f] – described in Chapter 11 – enables

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[a] At the inflection points between positive and negative curvature, corresponding to the body's surface.

[b] Russell Stannard, *Relativity: A Very Short Introduction*, Oxford 2008, P80

[c] At the inflection points between positive and negative curvature, corresponding to the body's surface.

[d] Remember that the 4th Dimension is not an isolated dimensional entity, but comprises the stacking up of all dimensions below it into the structure's nested hierarchy. In a simple sense we think of it as time because it is our means of change, but it is actually the block universe – all of space-time from start to finish – experienced by us sequentially, one single cross-section of which is 3D in the physical moment now.

[e] Time is a mysterious quantity within physics because it is a partial description (our 3D experience) of a wider phenomenon (the 4D block universe).

[f] *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.

us to set the anomaly of how we *experience* time aside, we are in a position to apply a *Flatland*-style breakdown.

> *Reflection…* It is critically important to bear in mind that as we apply the analogy to the dimensional structure, by the 4th Dimension we do not simply mean time, but all that time contains: i.e. the block universe.

In earlier chapters we examined the relationship between the dimensions and found that, by the process of stacking, the last physical dimension in *any* universe (the n^{th} Dimension in an nD universe) always acts as that universe's means of change. Each hypothetical universe is, like ours, locked in to the ongoing stacking of cross-sections into its last dimension, resulting in perception *from within*[a] of an ever-changing timescape which acts in one direction – radially away from each observer-point in the n^{th} direction in accordance with the *Magic Treadmill Principle*[b]. In our 4D universe this acts in a *fourth* direction:

- The past presents to our consciousness as a 4-Dimensionally radial 0D point which is therefore invisible, receding 'concentrically' with respect to the observer[c]. 3D nows have stacked up and set into what we think of as the past.
- The future is imagined, based on our past but not yet experienced because, from our viewpoint, future nows have not yet stacked.

Understood in terms of the overall dimensional structure, our 4th, or temporal, Dimension is not so much 'different' as 'currently stacking'[d]. Let's now look at what happens if we are willing to allow the 4th Dimension *proper* – the block universe – to *'accommodate'* the bending.

Communication Breakdown

But before we begin… as mentioned in point 2) above, because of the excessive use of the concept of 'curvature' we have all accepted that space-time is curved. At the risk of incurring the wrath, I will state plainly that I believe we have all been adversely influenced by the analogy, because space-time *itself* is not 'curved'. There is a very careful distinction to be made here: it is the *dimensionally lower analogy* that displays curvature, which applies *in principle* to space-time. In reality, space-time behaves in 3/4D *as curvature does* in 2/3D, which means that space-time itself is not *actually* curved – it is 'something-elsed'. Einstein described it as follows,

'In particular, the "curvature" at every point of the surface can be calculated;' [e]

Note his use of inverted commas around the term "curvature", which, according to the Oxford Dictionary[f] denotes 'arguably inaccurate use'. Einstein knows the limitations of the analogy, as does astrophysicist Stuart Clark when he calls the space-time continuum, *'a fabric – for want of a better word'*[g],

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[a] *The 'Edge-On' Principle:* Each dimension is viewed from within itself one dimension lower. See Chapter 9 for a full breakdown of this.

[b] *The Magic Treadmill Principle:* Time, as the nth Dimension in an nDimensional space-time, issues forth perpendicularly and radially from within the frame of reference of each space-time event. To the observer this nth 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 nth Dimension, taking the form of the past.

[c] This is explained more fully in Chapter 11: *The Magic Treadmill of Time*.

[d] However, it is not stacking uniformly throughout the Universe, but relativistically, because time is not invariant.

[e] http://www.britannica.com/topic/Albert-Einstein-on-Space-Time-1987141 - Accessed 17th April 2016.

[f] http://www.oxforddictionaries.com/words/inverted-commas - Accessed 17th April 2016.

[g] Stuart Clark, *The 20 Big Universe Questions*, Quercus 2014, P90

and Russell Stannard with his use of inverted commas on the word 'bending'[a]. Why should this matter? MIT Professor of Robotics, Rodney A Brooks asks, *'does the metaphor of the day have an effect on the science of the day? I claim that it does,..'* [b] Although Brooks is describing evolving high tech analogies of the brain, the point still stands.

Clearly there is nothing wrong with the use of curvature as a mathematical term to describe a pattern or function which runs through all dimensions, but as an analogy curvature should have a 'handle with care' sticker, because, as science writer Nigel Calder tells us, it is more accurate to say that *'Space is 'denser' in the vicinity of a massive body'*[c]. By training ourselves to think of space as curved we are allowing the analogy – i.e. the concept of flatness – to dictate our understanding, thereby denying ourselves the opportunity to get a handle on what is actually going on.

Ok, so what's going on?

The important thing is, we are not talking about area (which can curve), but volume. As already observed, we have no way to mentally picture the true situation because we only possess the capacity to deal with the universe as we find it: edge-on[d] in 3D. But out there in the real universe, energy and mass indicate the presence of a volume which somehow contains more volume, or '3-Dimensionality', than physically adjacent space. As Calder puts it, space is *'denser'*. 3D space dips into the enveloping 4D and adds to itself by borrowing extra 3D slices – i.e. additional cross-sections of 4D – from the 4th Dimension, by precisely the same mechanism as the lettuce leaf.

These 3D slices constitute extra 'physical moment nows' from the block universe as it grips the present. In other words, the present is beefing itself up locally by borrowing from the past and/or the future. In a dimensional sense we may think of the block universe as locally converting the 4th Dimension back into 3D slices. Time slows down in a gravitational field simply because there is more of it to get through, in the form of extra 'physical moment nows'.

As ever, the key is to remember that we are not talking about *'flat'* curvature which has length and width, and dips into height, but *'volume'* curvature which has length, width *and* height, and dips into the block universe. In this way, the 4th Dimension takes up the bending.

'Stein-Ball

Now, imagine you have a soccer ball which contains a certain volume, then you pump up the volume to increase the diameter... *without increasing the circumference or surface area*. A very interesting game would ensue! Like Dr Who's Tardis, this sphere is bigger on the inside than out. I know this sounds crazy and impossible but it describes a known General Relativity effect on a large massive object, and the greater the mass of the sphere[e], the greater the discrepancy. On P197 of his original paper on GR, Einstein writes that,

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[a] Russell Stannard, *Relativity: A Very Short Introduction*, Oxford 2008, P80

[b] Rodney A Brooks, *The Computational Metaphor*, from *This Idea Must Die*, Edited by John Brockman, Harper Perennial 2015, P296

[c] Nigel Calder, *Einstein's Universe*, Pelican Books 1982, P94

[d] *The 'Edge-On' Principle:* Each dimension is viewed from within itself one dimension lower.

[e] Of course it could be any shape, but masses in space capable of producing significant change would long since have experienced gravitational collapse to a sphere.

'Euclidean geometry does not hold even to a first approximation in the gravitational field,' although he points out that *'the deviations to be expected are much too slight to be noticeable in measurements of the earth's surface.'* [a]

However, they are noticeable within the Sun. In an excerpt from the classic, *Einstein's Universe*[b], Nigel Calder gives us more detail,

'Another symptom of the curvature of space is that the surface area of a massive body is less than you would deduce by measuring its radius and applying the euclidean formula ($4\pi r^2$). In other words the radius is too great for the area, and the 'excess radius' is proportional to the mass of the object.'

He goes on to say that the area 'missing' from the surface of the Sun is *'roughly the area of the USA'*.

Curious as to the specifics, in an online paper, *Calculations on space-time curvature within the Earth and Sun*[c], US physicist Wm Robert Johnston determines that, *'The relativistic correction to the Sun's volume is… about 6 times the volume of the Earth.'* Allowing for the significant effect of non-uniform density (increasing toward the centre) within these bodies, he concludes,

'Because of the curvature of space-time, the volume contained within the surface of the Sun and the Earth is greater than the volume enclosed by a similar surface in Euclidean space.'

'In the case of the Sun, this internal space-time curvature accords it a volume 6 parts per million greater than the Sun's surface would enclose in Euclidean space.'

'The true diameters of the Sun and Earth are 4.1 km and 4.4 mm greater, respectively, than one would expect from applying Euclidean geometry ($C = \pi d$) to the observed surface of these bodies.'

Although this may not seem like much, he goes on to say that for neutron stars the relativistic (non-Euclidean) volume[d] may be…

'…about 18% greater than the Euclidean volume. This suggests that relativistic space-time curvature is a significant consideration when modelling the interiors of neutron stars.'

From this we see that – in keeping with Einstein's observation above – any deviation between the volume and surface area of the Earth is unlikely ever to affect the price of cheese. Relativistic discrepancies due to mass come into play as a major factor only in extreme circumstances in the depths of space. However, no matter how slight, they are there.

Reflection… This suggests that the non-Euclidean volume of a black hole must tend to infinity. The mystery of how so much matter may be condensed to a single point is explained by the counter-intuitive nature of relativistic volume, resulting in *openness* in the 3rd Dimension, (or 3Dv and its consequence as deduced in the last chapter: gravitational diffusion). Although we find it hard to imagine a point that is infinitely dense, a 3-Dimensional space that is infinitely open is not so hard.

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[a] http://hermes.ffn.ub.es/luisnavarro/nuevo_maletin/Einstein_GRelativity_1916.pdf - Accessed 15th April 2016.

[b] Nigel Calder, *Einstein's Universe*, Pelican Books 1982, P85

[c] http://www.johnstonsarchive.net/relativity/stcurve.pdf - Accessed 9th April 2016. To be fair he states in his opening disclaimer, 'This is the outcome of a small exercise I engaged in with my tiny understanding of relativity; serious relativists please forgive me (and set me straight as necessary!)' Since no-one appears to have 'set him straight' since 2008 I think we're good to go.

[d] As Johnston points out, the critical significance of relativistic volume lies in the fact that, *'This curvature in turn determines the motion of freely falling objects.'*

Flatland-Based Interpretation

In the last chapter I used the term 'truespace' to represent the idea of 3-Dimensionality as a field of variable density. From the above we are now able to see very clearly that our universal field of truespace was a description of the non-Euclidean volume or true 'shape' of space throughout the universe. The truespace field (which, if you remember, was derived from the *property* of volume inherent within length, width and height as a *representation* of 3D proper) describes the openness/confinedness of the universe generally, as experienced by mass-energy and electro-magnetism – by the operation of the principles of *Stacking*[a] and *Character*[b] – within the dimensional structure. Now let's take a closer look at the question,

'How can the increased density of space affect time?'

Put simply, a massive object represents a greater 3D space than our universe has room for within that space. *'Space is 'denser' in the vicinity of a massive body'*[c] because the space-dent[d] occupied by the mass 'holds more 3-Dimensionality'. I represent this by the term 'volume-density', or 3Dv. The mechanism by which it achieves this we have already described as dipping into the next dimension up – the 4^{th} – and converting a portion of it 'back' into 3D slices.

Dimensionally, this volume-density of the field may be described in terms of an increased number of 3D slices of 4D within the body, which corresponds – one dimension up – to the dip in the rubber sheet (or, in principle, the lettuce leaf). Now imagine that you are an observer (which you are) passing through this gravitational field. The lower you are in the field, the more dense the 3D – in other words, the more 3D slices of the 4^{th} Dimension you would encounter, and therefore pass through. And more slices of 3D = (in the experience of the observer) more time.

Lumpy Gravy

In the rubber sheet analogy the curvature of the sheet passes from positive to negative, producing the effect of a field which extends away in all directions from the object on a reducing curve to infinity. This positive/negative changeover (inflection point) corresponds to the surface of the spherical object. In this way a massive object in space (e.g. the Moon) forms a non-Euclidean volume of open truespace whose influence (or openness) 'fades out' into more confined truespace. And of course, the greater the mass, the more 3D a massive body appropriates from the 4^{th} Dimension, meaning that its space-dent holds more 3D cross-sections of the 4^{th} Dimension than all surrounding space, resulting in – to use Newton's phrase – a 'ponderable body' which contains *more* openness than the confinedness of equivalent Euclidean space.

Newton himself touched on this idea (see box below) but, in the absence of a relativistic mechanism, related it to the aether. But his scientific instincts remained, as ever, uncanny.

The whole of space is like very slightly lumpy gravy, comprising vast tracts of space punctuated by tiny massive objects and systems (stars, galaxies etc) – smooth and homogeneous overall, but 'lumpy

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[a] *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.

[b] *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.

[c] Nigel Calder, *Einstein's Universe*, Pelican Books 1982, P94

[d] The space-dent may be thought of as a 3D 'dent' in the 4^{th} Dimension in the same way that the rubber sheet produces a 2D 'dent' in the 3^{rd}.

smooth'. However, viewed dimensionally this situation becomes counter-intuitively reversed, because truespace[a] has an inverse relation to the normal volume of space with respect to openness and confinedness, enabling gravitation to act entropically by an emergent process resembling diffusion, as described in the last chapter. In other words, the lumps are lumps of *openness* in a universe of *confinedness* in the 3rd Dimension proper.

> *Reflection…* In this chapter I describe relationships between massive objects within the dimensional structure. However, the gravitational field is itself an emergent phenomenon, the result of the distribution of individual 'point-masses'. The relationship of one point-mass to another will be discussed in Chapter 35 when we come to look at the dimensional root causes of gravitation and expansion. But *please* don't skip forward as these in turn rest on the shape of the universe and a thing called '*Centre A/B* recession' to which our *Flatland*-based Dimensionality points. Things are just starting to hot up!

Give Me Just a Little More Time

At this point let's remind ourselves of what is meant by a 3D cross-section or slice. This was addressed in Chapter 17, *The Physical Moment Now:*

> The present ***is*** the physical universe at any given moment, which builds in cross-sections into time. But, *that is all it is*. It is not a 'time' moment, or even a 'space-time' moment, because space-time is something different, but a 'space' moment. We are part of it and we can reach out and touch it. The moment now is a timeless 3D physical thing.

A 3D slice or cross-section *is* the present – the exclusively physical moment now *in the experience of the observer*[b]. Therefore, if one 4D location contains more 3D slices than another, it follows logically that ***it must contain more time***.

A curious effect of General Relativity is that time actually passes at a slower rate for anyone or anything within a gravitational field[c]. This is known as gravitational time dilation[d].

Russell Stannard tells us that,

> *'…what we find is that in a gravitational field, a clock – and hence time itself – runs slower the lower down in the field it is.'*
>
> *'To an observer far from the sun, a clock close to the sun appears to go slow… The closer the clock is to the sun, the slower it goes. For stars heavier than the sun, i.e. with larger mass,* ***m****, the effect is greater.'* [e]

We now have a picture in dimensional terms of why it is that time slows down in a gravitational field: a body's gravitational field contains more 'physical moment nows', therefore it has *more time to get*

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[a] Which corresponds to the universal gravitational field.
[b] The physical moment now is not to be thought of as universal simultaneity, but obeys the principles of Relativity at each space-time event.
[c] The effect is extremely slight at Earth's *g*, but enough so that its effects must be taken into account by GPS.
[d] Gravitational time dilation continues to a maximum at the centre of, e.g. the Earth, in spite of the fact that the equilibrium of gravitational pull results in the cancelling out of 'felt' gravity. In dimensional terms, this might be understood in the same sense that a diffusing particle at the centre of a room has arrived at a place where its movement options have 'equal probability'.
[e] Russell Stannard, *Relativity: A Very Short Introduction*, Oxford 2008

through within the same period than a similar period measured outside the field. The greater the mass, the more 3D slices its space-dent appropriates, or 'borrows', from the 4^{th} Dimension, and consequently the more 'moment nows' it contains. A simple way to express this might be to say that ***the mass of an object contains more instances of the present than surrounding space***.

From this, the mechanism that causes gravitational time dilation may be thought of as the 'shape', or local volume-density, of the truespace field. Interpreted in terms of the overall dimensional structure, this 3D appropriation or borrowing is in turn the result of stacking up of 2D, and because 2D corresponds to mass-energy (see Chapter 15), the dimensional structure reveals why a body's gravity is proportional to its mass.

Space-Plus

Since it is more correct to think of the 4^{th} Dimension as the block universe than simply time, with the physical moment now as the 3D slice that divides it at each point-event into past and future, the massive object is not merely borrowing slices of 'time' from enveloping 4D, it is borrowing slices of *'already stacked into 4D'* truespace by converting these back into 3D in the same sense that the lettuce leaf converts the 3D around it back into 2D. In this way the variable field of truespace corresponds to the universal gravitational field – Albert Einstein's field of space-time curvature.

In a kind of way it would make more semantic sense for space-time to be called 'time-space', with 'time' as an adjective to describe, or at least allude to the source of non-Euclidean space's difference from Euclidean space. However I mention this rather sheepishly in passing since it was, I believe, the great man himself who named it!

At the end of the day it might be good to upgrade the idea of 'time' in this context to 'volume possessing density', because it is the local increase in the volume-density of truespace that gives us the sense that what is going on is somehow a blend of space and time. As ever, it is important to grasp that ***these are not time moments, but space moments***; physical 'freeze-frames' to which we attribute the phenomenon of time because the exchanging of one for another facilitates change in our experience.

The perhaps rather startling conclusion of this is that – although space-time is 4-Dimensional in the sense that it mimics the block universe by 'appearing' to stack up 3D slices, and in the sense that it borrowed these from the 4^{th} Dimension – in the particular moment now of the observer ***space-time remains a field of variable 3-Dimensionality***. It performs a dimensional conjuring trick, an illusion of 'space done-up to look like time', so when the physicists go to look for time within the equations of GR as a dimension in its own right like the lower three, it is not there. In this way the equations have always exposed this '4D impersonator' (t) for what it is.

Einstein wrote that,

> *'in the general theory of relativity the space-time-concept refers to the behaviour of rigid bodies and clocks.'* [a]

From this it is easy to see how space-time cannot truly penetrate the 4^{th} Dimension, because it does not describe 3D's stacked-up state as fused together, but instead the relative status of observers, lengths of objects, and clocks, as each experiences itself in relation to all the others within the 'now' of each observer's discrete slice. As a result, space-time itself – although the product of a 4-Dimensional theory involving the

[a] https://www.britannica.com/topic/Albert-Einstein-on-Space-Time-1987141 - Accessed 29th Jan 2017

passage of time and a ‘dipping into’ 4D – turns out to be 3-Dimensional when considered in terms of our *Flatland*-derived dimensional structure.

Space-time is really just 'space-plus'[a], and if we use it to try to understand the mechanism of time it will not divulge its secret. It simply cannot tell what it does not know.

Of course, whether or not these borrowed 3D slices were ever *actually* stacked into the 4th Dimension is unclear (or at least it is unknown to me) but it seems reasonable to think of them as somehow ‘converted back’ into 3D so that each may be experienced as the present. In this way, as per the lettuce leaf effect, the 4th Dimension proper ‘takes up the bending’.

As there would seem no reason why the block universe itself should make any distinction between past and future, it is quite conceivable that the massive object's borrowing envelope extends, not in one direction as per the limited up *or* down analogy of the rubber sheet, but up *as well as* down. Understood in this way, the gravity well could extend the 3rd Dimension into both the past and the future, 50/50, with the mass gliding along like an oiled ball bearing between two silk sheets on a weightless spacecraft.

[a] This is in the same sense that the lettuce leaf is ‘2D plus’, because, although the whole surface of the leaf (being frilly) may be thought of as occupying a 3-Dimensional space, its surface *remains* 2-Dimensional’