Unitarian Sermon 20140727
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I am grateful again to Rosemary Arthur two services ago for providing me with a subject for this week's sermon and, in part, service. Rosemary handed out Mandelbrot designs that are a feature of mathematical chaos. However, she also discussed chaos from different angles, using its more common meaning and psychological too.

What is chaos? Well imagine a sand hill in a desert with a prevailing wind. Sand grains drop on it from the wind one at a time. It forms a pattern, a sand dune, like a fractal does, which builds and builds. But at some point a grain of sand is added that is the critical one that results in an avalanche. It is like asking in an economy of buying and selling which single refusal to buy is the critical one that turns an economic boom into a bust. One minute in 2007 the banks were lending and next minute a refusal was a pivot point into a major economic crisis.

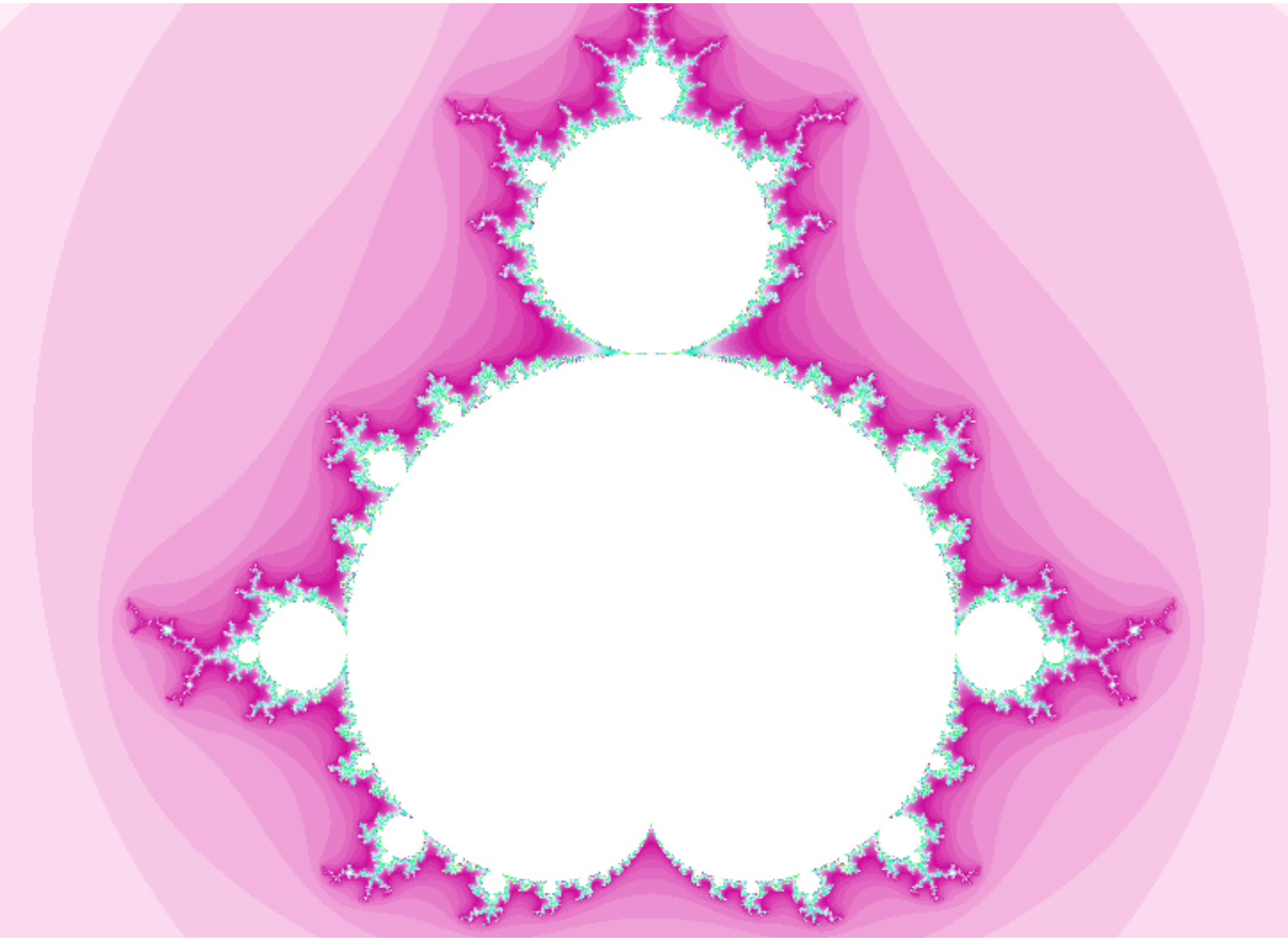
Anything that involves simple one-to-one manoeuvres and responses within continuous flows of actions becomes chaotic, whether grains of sand on a sand dune or individual actions in an economy.

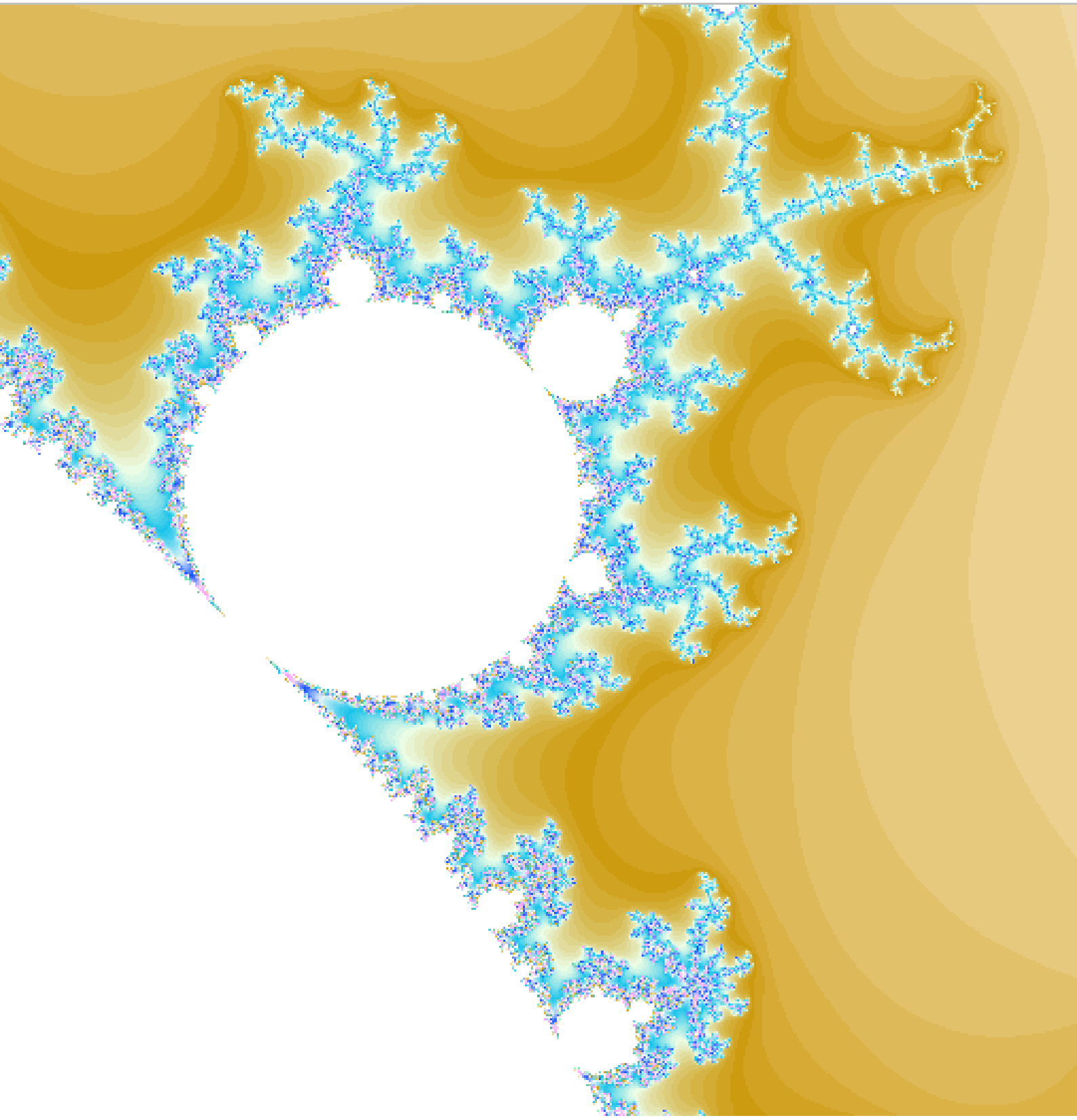
Yet it is possible to do mathematics of chaos - of the Self Organising Criticality involved: where chaos isn't exactly chaos bur rather patterning that has unpredictability in its formations and alterations.

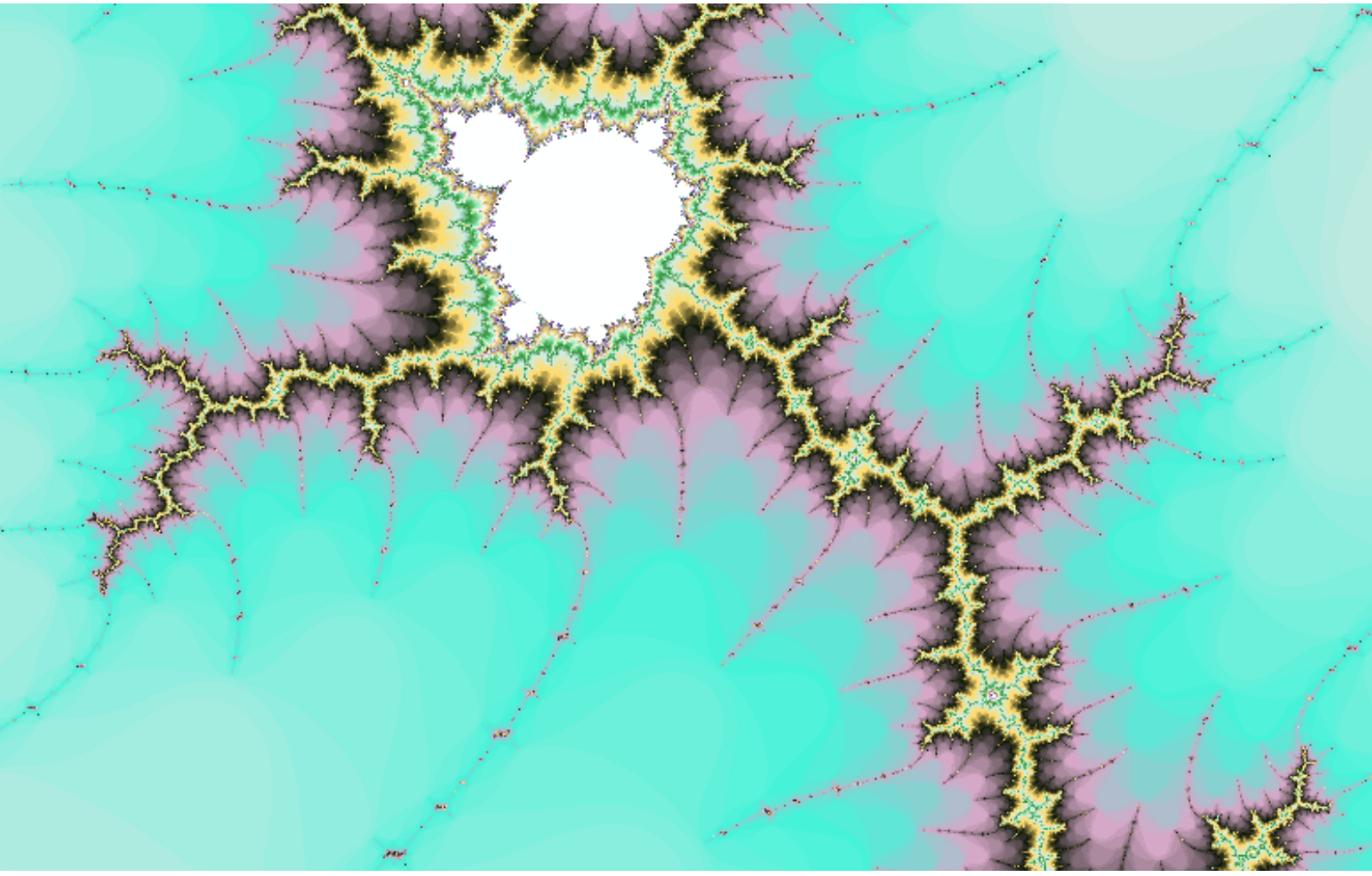
The point about the *Mandelbrot* set, or the *Julia* set, or indeed any fractal, is that they are predictable diagrams once you put the figures in. They are not chaos in a common sense understanding of chaos. The *Mandelbrot* set, a particular iterating equation, looks, interestingly, like a Buddha - well, a Buddha with an aerial on top and seahorses between the head and body. One form of rendering is indeed called *Buddhabrot*, where pixels vary in brightness, as others vary in colours.

Here is an explanation. In maths you cannot square a number and produce a negative number. For example, minus 3 to the power of 2 is still plus 9. But if you may force a negative outcome, so that i squared (i^2) is allowed as a minus 1 as well as 1, then you deal in complex numbers. Deal in complex numbers, and strange things start to appear.

The Mandelbrot equation is Zed equals zed squared plus C ($Z=Z^2+C$) where Z and C are complex numbers. You can see that Z changes because it is squared with C added. C is like a location being tested, and







the equation declares Z within -2 to 2 for which a plot is made and Z is changed again. If C is immediately outside Mandebrot, it is black and the test stops. Or a C may may be confirmed as inside Mandelbrot several times, for which the colour changes or brightness increases, and when it comes outside, a new plotting point in the complex zone or a different C is then tested. As each C is confirmed or rejected, the *Buddhabrot*-like shape grows in its colours or brightness.

We can think of a complex number as being virtual - it doesn't exist, except by analogy in a mirror. Complex numbers are like *Alice Through the Looking Glass*, when Alice's world looks just like ours. Indeed, Cliff A. Pickford wrote *Chaos in Wonderland* in 1994.

Now the fractal is a product of the computer age, starting in 1978. Mathematicians need computer speeds to plot precise and increasingly tiny complex numbers to make fractals. Computers display these diagrams ever deeper in form revealing the organisation of both difference and self-symmetry.

If we do only one iteration for C, to plot inside or not, and then, regardless, change the C, we get a plot like an ellipse for these Cs. If we do the sum again on C, and again, but stop at an early pre-determined point, the appearance is more like cells dividing and grouping together. Only when the iteration continues does the fractal shape emerge.

Does this give a clue about anything? Cells dividing and later making particular shapes? Could this be, for example, the secret information behind cellular division in life?

Go deeper and deeper into a Mandelbrot set (adding ever more zeros after the decimal point) and little Buddhas appear from all over the place. A tiny wriggly bit of the Buddha's head seems to produce, deeper and deeper, another Buddha. Or go off that Buddha's shoulder, and later comes a Buddha again.

At some point you stop it or your computer will stop - because the minus zero zero zero zero zero etc. numbers of C and affected Z are just too small even for it to do the maths. The plotted diagram comes to an end.

And here is an interesting thought. The maths should be the same every time leading to the same fractal. However, the tiniest errors or variations in rounding up causes mutations - and where have we heard about that

before, if not in the mutations of cellular life? Mutations are the variations that drive plant and animal evolution.

In the real world fractal shapes (other iterating complex number equations) are found in all sorts of places. So, for example, a fern leaf is an oft-produced fractal shape. Is there a reason, therefore, that one of the first plants produced in this earth and covered the planet was a fern? What is it that governs its shape? A simple fractal equation, perhaps.

A tree, I suggest, has the qualities of both symmetry and asymmetry. A satisfactory tree when painted should show left to right leaves as well as balance up and down in structure and form. Why is this? Does it suggest that a seed contains a fractal equation?

A flower is a combination, is it not, of symmetry and asymmetry?

A coastline is fractal. Why? Look at a coastline on a map and then look at a coastline beneath your own feet. The tiniest sand grains at the border with the sea have the same symmetry and asymmetry as the squiggles on the map representing billions of sand grains.

Now back in 2010 I made a blog entry that was linked from the BBC. Matthew Collings, who is an artist and art commentator, did a programme on BBC 4 called *Beautiful Equations*. You heard a six and a half minutes of its crucial reflections. My blog entry is the ‘Theology of the Beauty of Equations’, dated 16th December 2010. Unfortunately the link from the BBC is no longer there, nor is the programme available on iPlayer. But it is on You Tube.

Matthew Collings wants to know why scientists talk about beautiful equations and whether their notion of beauty relates to an artist's notion of beauty. He tries to learn what the equations do. What about a theologian: what do equations as 'beautiful' mean to a theologian?

Here's a famous one. E equals M C squared ($E=MC^2$). M is Mass and C is the speed of light through empty space. The equals mean two sides are in balance. The equation shows that half a gram of mass becomes 45,000,000,000,000 jules - or, roughly speaking, a pill produces 15 kilotons of TNT in energy. So this E=MC squared has been tested. It is found to be true: the maths was turned into objective research. The equation was a prophecy before it was shown to be universally true, by testing.

Einstein said that the only physical theories we are prepared to accept are the beautiful ones. That's astonishing, isn't it, and what does this mean? It means equations should be simple to write down, even if they need a lot of unpacking.

What about time running at actual different rates depending on how fast you are moving? The equation for that - from Einstein again - is T prime equals T over the square root of one minus v squared over one minus C squared.

$$T\prime = T\sqrt{\left(1 - \left(\frac{v^2}{c^2}\right)\right)}$$

Now, even if this is meaningless to you or me, you surely must admit that states something so astonishing - that time runs differently for me and you according to how fast each of us moves. But it is true and it is universal and it has been tested. A moving train's clock T prime runs slower than a clock T on the station platform. Now, do the maths and the even an Intercity 125 is so slow that the difference is infinitesimal between the two clocks - BUT the clocks DO run at different times. This has been tested - for example, atomic clocks that orbit the earth at speed run more slowly than the same clocks on the earth itself.

The equation states that if the train runs at the speed of light then time on the train relative to the platform completely stops - the station would get old infinitely quickly. In other words, travellers on *Star Trek*'s Enterprise would come back to a dead earth and find all their brothers and sisters and every generation of offspring having lived and died.

Incidentally the same variation of time happens if you are afraid. A test was done, by Dr David Eagleman of Texas University, as highlighted by Michio Kaku, on a person undergoing fear. The common notion is that when you are afraid you think things happen more slowly. You remember a car crash; it is vivid and even slow. But that's, in part at least, because time does slow down. In Eagleman’s experiment a timer attached to an

arm was run faster to a point where the observer could not see some numbers change - they became a blur. Able to view the timer, the person was dropped from a twelve storey height to induce fear, on to a safety net, and the person could see numbers previously unseen as a blur. What this **proves** is that time doesn't just appear to slow down when we are afraid, **it actually does slow**. It is an objective test of the effect of adrenaline. Perhaps maths has resulted from the test. Maths is about relationship and structure - it is easier to go from the maths to object orientated research. The experiment nevertheless proves that time actually slows down if we are afraid. Cocaine causes time to increase, and marijuana causes time to slow down.

Now Matthew Collings considered five universal equations. He didn't consider fractals but I'd like to say that the Mandelbrot equation is incredibly short and simple, plus Clifford A. Pickover, a mathematician and computer artist, wrote a book in 1990 called *Computers, Pattern, Chaos, and Beauty*.

The equation is universal, and prophetic. The maths comes first and predicts; the tests confirm the maths through repeated results. Mathematicians surprisingly call it 'painting the world' when an equation is used to describe actual reality - being subjected to the test of research.

Here is the important point. We are not talking about myth but actuality. Those thoroughgoing philosophers who say symbols simply point to themselves in a non-realist way defy the reality of the beautiful equation.

There is, instead, I suggest, a hierarchy of knowledge. First is maths, which is relational and structural, and then comes physics, which is objective based research. Then comes chemistry, then biology and then the problematic science of psychology including forms of deep grammar. Then comes social sciences like sociology, where research looks for patterns of quantitative regularity and qualitative validity, then I suggest geography borrowing from spacial maths and social sciences, along with history because of the rules of historiography, and only then do we have the creative arts and pure religion. In other words, religion itself, unsupported by science, or social science, or history, is one of the most subjective of forms of knowledge.

What makes a good painting? Perhaps use of the golden mean, the colour wheel, and the skill of the artist. But a good painting may defy these cultural rules. What makes a true religion? Indeed is there such a

thing at all, other than exchanged myths and experiences? Your God is your imagination, and my God is my imagination.

The reason why I am no longer a non-realist in religion - even though I am in the same place - is because of the relationship of religion to the rest of knowledge. Knowledge is a hierarchy of objectivity and subjectivity. The Unitarian James Martineau said religion was all ultimately individualistic, and his shared liturgies were to generate individual feeling through common repetitive yet updated symbols.

We notice, however, that real-world subjectivity has an objective element - such as when fear slows down time just for me, just for you. Time on the moving train is slower, just for them, or quicker on the platform, just for them. So these subjective realities are objective in research.

But if I paint a picture or write a novel, I cannot step into them and prove their existence, even for me, or even for my characters. This is purely imaginary. When I was a child there was a man who painted a door on a wall and then he opened it and went into a new outdoors world. I was fascinated and even frightened. But in the arts we cannot do this. Picasso and cubism may have responded to relativity but is only reflective, like religion.

Buddhism also deals with the individual presence and with collective deep paradoxes that defy common sense. But Buddhism says these transitory conditions are still real. Thorough-going postmodern non-realists say that words in a dictionary are defined only by other words in a dictionary, and all symbols including mathematical ones are their own. But this is an absolutism, a fundamentalism, of language. Yes, language is a filter, but it is only a filter and not self-contained.

So here is a theology that is reflecting upon objectivity. It is saying: here is a transcendent principle. The small equation transcends. Bertrand Russell famously wrote in his essay ‘Mysticism and Logic’, “Mathematics, rightly viewed, possesses not only truth, but supreme beauty.” Paul Dirac is a key mathematician, because he insisted on the principle of mathematical beauty, and it was indeed a kind of religion to him. He said, “The search for beauty powers the advance of science.”

How about the hidden Unitarian called Isaac Newton? Newton wrote no equations! He used Latin to say that what is falling to earth is really pulled to earth. In the *Principia Mathematica* Newton wrote:

Si gluborum duorum in se mutuo gravitantium materia undique in regionibus, que a centris aequaliter distant, homogenea sit erit pondus globi alterutrius in alterum reproce ut quadratum distantiae inter centra.

That's a verbal sweet nothing to me. It is, however, in the end, an equation. It's just in Latin. In simplest English, the bigger the objects and the nearer they are the more is the gravitational pull between them. An apple falling to earth becomes two Newtons - that's the force. What we know from Galileo is that all objects in any one setting are pulled at the same rate. On the moon a feather and hammer fell at the same rate, if slower than the same rate they fall on earth. We know it from Newton too, factoring in Newton's effective equation for the law of motion:

$$a = G\,M\,\frac{M_1}{M_2}\,\frac{1}{r^2}$$

Isaac Newton had a brilliant mathematical mind. He was unitarian in theology, but of the kind in his day. Newton also believed that the Bible contained a secret code and wasted years of brain power trying to decipher it. He just didn't understand the hierarchy of knowledge. His effective equation for gravity still works in the immediate confines of its application - Einstein relocated the concept of gravity into spacetime.

If mathematics is the most reliable symbol system, even if incomplete, then something profound is being said about transcendence and beauty. I am myself rather like Matthew Collings: trying to make sense of the equations and their beauty in a different sense - in a more theological sense.

Why then call it chaos? Because in our object based world, we can never measure sufficiently precisely where we are when any chaotic system gets going. Chaotic systems include the sand in the desert, the weather, the climate, evolution, the economy, even international politics. The first world war was an example of a chaotic system where one single murder of an archduke led to all-out world war. **We** only have to contend with Israel/ Palestine, Iraq, Islamic extremism and the ex-Soviet Union.

What makes chaos stable is that at higher levels forces work against each other to bring about a balance or equilibrium. For example it is

chaotic that rabbits and foxes appear, from their evolving origins, but the effect of many foxes eating many rabbits is to stop the population of rabbits and foxes increasing too rapidly and then crashing through starvation. In other words, systems impose stabilising equilibria - but only most of the time. Things do go wrong, as with the economy recently.

So this is also interesting, isn't it, because the system with equilibrium is another form of transcendence as it makes chaos bearable.

So: transcendence. In 2005 Clifford A. Pickover wrote a book: *Sex, Drugs, Einstein, and Elves: Sushi, Psychedelics, Parallel Universes, and the Quest for Transcendence*. So we ask, is the balance of a beautiful equation transcendent? Is the simplicity at the heart of complexity transcendent? Is the system that allows chaos to be bearable and workable transcendent? Is such transcendence God? What about prime numbers and pi - pi discovered in the Mandelbrot fractal in 1991? Or are these just signals of transcendence - clues to what God would be in the last remaining mythical non-realist sense? Well we each decide this, subjectively, like we decide whether a painting is good or not. But this is what Clifford A. Pickover's 2009 book was called *The Loom of God*: *Tapestries of Mathematics and Mysticism*. He wrote that: "Mathematics is the loom upon which God weaves the fabric of the universe."

* http://pluralistspeaks.blogspot.co.uk/2010/12/theology-of-beauty-of-equations.html
http://www.pickover.com/
BBC Beautiful Equations (2010, Uploaded 13 Nov 2012) [Online] https://www.youtube.com/watch?v=erUQhXjY9ic [Accessed: Thursday July 24 2014, 19:25]

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