3 The Time Explorer’s Toolkit

The French philosopher Auguste Comte was probably the first to observe that there is a top-down (broadly pyramid-like) hierarchy in how nature builds upon tiered foundational layers to yield up the rich, multi-tiered reality we experience. Closer to us in time, the physicist Richard Feynman once described the universe as an endless series of onion-like layers, each layer presenting us with a fresh set of comprehension challenges.

This hierarchy is directly reflected in the sciences. Simply put, physics, or equivalently the laws of physics, allows physical chemistry to happen, which in turn enables chemistry which then enables organic chemistry which enables biochemistry which enables psychology which enables, say, criminology. Of course, in reality it is slightly more complex, both because there are many more layers and any given layer may spawn several parallel sub-layers, in such a way that smaller pyramids begin at every level, but also because of the phenomenon of ‘emergence’, which we will be looking at more in depth later on, but which in essence means that at any deeper level of the pyramid, new phenomena that were in principle not foreseeable at the immediately higher-up level might crop up.

The question is, of course, what sits on top of physics, the uppermost layer in the foregoing paragraph. Then the next questions will be what, if anything, sits at the very top above all the other layers? How can we prove that any given layer is at a given place, and not located somewhere else - further down or further up - in the hierarchy?

For instance if, as we shall now see, mathematics sits on top of physics, the immediate and legitimate question that arises is - how do we know that mathematics enables physics and not the other way around? We could legitimately hold that mathematics was invented to count physical things - such as pots and bushels of corn and other material wares - and thus that mathematics is an emergent, artificial property of the physical world, made up by the humans who emerged from nature’s evolutionary processes, and not the other way around. As we will prove however, mathematics sits atop the pyramid above physics, which in turn enables the physical world. The next legitimate question will be whether there is anything that sits above this layer, and (where) does the pyramid stop?

Before we can explore mathematics further, a word about what it actually is, is called for.

A trawl through online discussions on the subject quickly shows that the very word ‘math’ can mean quite different things to different people. Only one narrow, precise definition holds here, so it is essential that we first specify what mathematics is, specifically: how valid ‘mathematics’ or valid ‘mathematical equation(s)’ are defined.

There are broadly speaking two kinds of mathematics, quite separate in their very essence as well as in their approaches and uses: pure mathematics on the one hand,
sometimes called *abstract* math; for instance pure geometry or number theory; and *applied* mathematics on the other hand, often called *mathematical modelling* when used to analyze something or when applied to the engineering description of some phenomenon, system, or machine (mathematical modelling routinely makes use of all kinds of sub-categories of applied mathematics, such as numerical analysis, finite element analysis, and so on). Pure mathematics is what we are dealing with here.

Broadly speaking, mathematical modelling consists of using numbers to roughly represent how an evolving system behaves, to predict its evolution, or the evolution of its parameters and properties in time; most often at the cost of making simplified assumptions. Briefly described, producing a mathematical model for a given phenomenon or evolving system involves combining a set of equations that relate known inputs (such as speed, temperature, or mass) in such a way as to calculate the resulting values of sought-after outputs describing changes to the system over time (such as trajectories, chemical, or geometrical changes). From this understanding it can be seen that the values of the outputs are inferred from the set of inputs and the evolution that these inputs go through in time as the system evolves. For our purposes, this is *not* what we will call mathematics here. Hereafter the book refers to mathematics in the sense of the laws of *pure* mathematics only - unless specified otherwise.

No one has put it better than David Hilbert: “We are often told that pure and applied mathematics are hostile to each other. This is not true. Pure and applied mathematics are not hostile to each other. Pure and applied mathematics have never been hostile to each other. Pure and applied mathematics cannot be hostile to each other because, in fact, there is absolutely nothing in common between them (9).” Mathematical modelling does indeed use a subset of math, much the same as, say, surgery uses a subset of biological science - but it is a wholly different animal from pure math. Whereas mathematical models of reality are obviously man-made and constitute attempts to understand and predict how nature operates, there is an ongoing discussion among scientists whether pure mathematics is in fact innate to nature, rather than a mere product of human intellect and thoughts.

In the sciences, experimental evidence is used to confirm that a theory is usable, at least within its given domain of applicability. If a theory is ever *proven wrong* by experimental evidence (also called *falsified*), then the theory is either wrong or is an approximation, with a validity zone (within given thresholds of accuracy) limited to a specifiable and calculable domain.

Physical reality conforms only to *correct* and *applicable* mathematics, and could even conceivably reflect all of mathematics: Miles Blencowe and Michael James Duff stated in their paper ‘*Super-branes and Space-time Signatures*’ that “we could think that external reality requires that more than one theory, and quite possibly all theories allowed by mathematics, be true.”

But how do we determine what ‘correct and applicable’ means? The question mostly arises with mathematical modelling and applied mathematics. Pure mathematics only *is*, and is always valid on its own abstract terms. Any practical
validity it may turn out to have is often found afterwards, sometimes serendipitously - no intended use was sought during its formal development.

As far as applied mathematics is concerned, it can so happen that it is formally correct yet bereft of meaning, in other words that it is correct in terms of fitting the logical rules which lie at its foundations, yet lacks any predictive or explanatory value, as follows:

Imagine that there are 2 dot points on a blank sheet of paper and you are asked what curve or drawing passes through these two points. You could say a line, or equally well a circle, a squiggle, a Picasso sketch, or otherwise.

In math terms, the two experimental points constitute two variables (the 2 points). These two variables will satisfy any number of ‘equations’, i.e. the many different curves and drawings that can pass through these two points, and at this stage of the proceedings you have really no way of knowing what the larger picture is.

The same holds in mathematical modelling: let’s say that you conduct a lab experiment that yields a total of 10 values, and that you are trying to work out the physical laws that govern the experiment; all you have to do to work out a mathematical model that seamlessly and perfectly fits all ten points is to define 10 variables. An equation with 10 points and 10 variables can be solved every time, and will yield a mathematical law fitting to a tee to your experimental results.

You now conduct one more experiment and you find an eleventh point that does not conform at all to what you would have expected from the model you worked out from the first ten experimental points. Well, not a problem! All you need to do is just add one more variable, and presto, you quickly end up with a new law that fits seamlessly all 11 points.

The example provided can be expanded to any number of experimental points: one can always come up with a mathematical model that fits all of any given set of data - but the model is however may yet not be applicable to a wider scope of its use: the next experimental point will likely not fit the model that was created from all the previous experimental data points. In other words, the model in this example has no predictive power and thus does not reflect the underlying reality behind the experiments (this can be imagined otherwise as if we had inferred from 3 dots that the curve on the above sheet of paper was a circle, but the fourth data point seemed to indicate a square, 1000 dots hinted at some pointillist drawing, or, you may theorize on the basis of many points that an unknown figure is a squiggle. Yet, confrontation with experiment - aka seeing the real drawing - shows that it is in fact a Piet Mondrian cubist drawing, and so on). Underscoring the danger of falling into this trap, some critics say that a similar phenomenon currently plagues some areas of string theory.

This is one of the reasons why an underpinning of models by using experimental data is required; any number of fitting laws and models can be inferred from any finite number of experimental points – laws which may however turn out to be sorely wide off the mark. The purpose of mathematical modelling is never to understand or explain reality; it is to provide a workable model of something that may be utilized within a given range of uses and operating environments. Mathematical modelling does not care if it is only approximate or only approximately valid within defined ranges: the only thing that matters is whether it is useful.
There exist many examples of phenomena that can seemingly only be explained by nature’s necessity to conform to valid mathematics. We will cite the ‘quantum jumps’ of atoms, the explosion of nuclear bombs, but there are many more. The Big Bang itself is likely one such phenomenon, as we shall see.

In the competition between physics and math to determine which comes first and sits atop the other in the Auguste Comte hierarchy, it turns out that the evidence in favour of mathematics sitting at the apex is overwhelming – even when allowance is made for the widely different interpretations that even incontrovertible experimental results can conjure up. This is why the famous mathematician Carl Gauss, and indeed many others such as the Oxford mathematician Marcus du Sautoy, have called math the ‘Queen of Sciences’. One of the great current debates in science is, in essence, whether math is invented or discovered. If it was invented - originally a language meant to count wares and money, then it is just that - a descriptive, utilitarian language made up by humans with no further value. If it was and is being discovered, then it is of central importance to any hope of understanding reality. Math, ranging from the simple to the complex, has been found to be deeply embedded within the natural phenomena which we have observed so far, and appears to be independent of us. To take but a simple example - the sequence of Fibonacci numbers is found in many natural structures in nature, such as fauna shells, can reasonably be seen to be innate. Man's contribution to these numbers does not extend any further than the fact that we labeled those numbers - we made up a name for them. If humankind were not around at all, the Fibonacci numbers would still be around, unnamed and unrecognized.

There are also whole swathes of pure math that still lie wholly unexplored and there exists whole new landscapes of math that remain to be discovered in future – of which we have as of yet no clues whatsoever to help us reveal. There are quite possibly areas of math that will never be uncovered by humankind.

Of those areas of which we do have an inkling, there are many where our abilities prove, at the very least, not to be adequate. For example the remaining so-called 'millennium' problems, which we are as yet unable to solve despite the efforts of stellar mathematicians who have spent their lives and careers attempting to solve. If math were purely man-made, we would likely solve those problems. What we discover at every corner of our exploration of math is that it is immensely bigger than us, and try as we may we cannot bend it to our will: its existence lies outside of us.

As Max Tegmark, a professor at MIT and a founding director at the Foundational Questions Institute, puts it: if we distinguish between two ways of viewing a physical theory, the outside perspective of, say, a scientist studying the math equations describing the theory, and the inside perspective of an observer living inside the world described by these equations, then we can take two opposite views: one possible approach is to say that the inside view is the real one, and the outside view with all its math baggage just an approximation made by humans trying to make sense of their world (this latter view sometimes known as the Aristotelian view.)
The other approach is the exact opposite: the outside view is real and reality is at its base nothing but an abstract mathematical structure, whereas the inside view, along with all its complex human baggage, is but a by-product of the structure and nothing really but a series of side effects - or epiphenomenons - i.e., useful approximations used by humans to describe their coarse perception of a precise underlying mathematical edifice. In that scenario, also known as the Platonic view, we are self-aware substructures (SAS) within a mathematical multiverse. The word mathematics, aka math, shall be consistently used here in the Max Tegmark meaning of an underlying structure to reality – irrespective of any other vocabulary used to describe it.

There are those who adopt the viewpoint that all of mathematics is wholly artificial, and that it is impossible to prove any truths whatsoever - both within the fields of mathematics and logic, or by means of math or logic. Under this view, sometimes called the Münchhausen trilemma, or equivalently Agrippa's trilemma, the proof of any theory rests on circular reasoning, or on infinite regress, or on arbitrary and unproven axioms; and numbers and other mathematical constructs are pure figments of the mind. Axioms are the unproven statements (albeit most often derived from observing nature) which provide the formalized foundation upon which any branch of mathematics is built and put together. A good example would be the foundational axioms (also called postulates) of Euclidean geometry, such as ‘a straight line segment can be drawn joining any two points’. This is an affirmed but unproven, and indeed unprovable assertion, which therefore cannot be used as such to demonstrate the fundamental truth or reality of anything.

However, far from being unproductive – the very fact that axioms are unproven has enormous value as it permits to delineate an overall envelope of possibilities - i.e., to circumscribe the outer limits of all the domains of possibilities and impossibilities within a relevant context (for example, geometry). This realm of possibilities and impossibilities can usually be precisely scoped out and the areas of ‘impossibility’ under a specific class of axioms can be investigated. This concept pushes the envelope and allows for exploring possible alternate realities, including such domains as may be not apparent or initially appear counterintuitive.

For instance in geometry mathematicians have been able to explore what happens when the base axioms of Euclidean geometry are held to be invalid precisely because these axioms are unproven but merely asserted. This analysis gave rise to valid non-Euclidean geometries such as the Riemannian and Lobatchevsky geometries, as well as higher dimensional geometries; all of which turned out to have real-world applicability in specific environments. Thus, it helped precisely scope the domains of the possible - and no further geometries were found to be conceivably able to exist beyond these three.

Other branches build from straightforward vocabulary definitions describing an otherwise irreducible underlying reality (such as the assertion that by definition ‘one and one is two’. Two is thus defined as being one and one, and it does not matter
whether two is called ‘deux’, ‘zwei’, ‘ni’, ‘iki’, ‘dwa’, ‘molemmat’, or anything else: whichever label is used, the underlying reality is the same and is not, regardless of label, subject to any assumption or further interpretation. Some people still do take the view that numbers and arithmetical operations such as, say, addition, do not reflect an objective external reality, but are merely axioms - namely Peano’s axioms. The Italian mathematician Giuseppe Peano (born 1858) formalized arithmetic and numbers through statements which he called postulates, or axioms.

We shall simply disagree here with those who say that both natural numbers and their relationships as expressed by the arithmetical operations of addition, subtraction, division and multiplication are fully axiomatic, but take the view that, irrespective of the latter-day formalization of arithmetic as laid down by Giuseppe Peano, there does exist independent de facto sets of numbers and arithmetic identities. Consistent examples can readily be found in nature; whenever a 30-strong pride of lions breaks up into two prides because it has become unsustainably big, the resultant two prides still have a combined total of 30 animals irrespective of whether addition and subtraction were duly formalized within an axiomatic framework. Hadn’t Carl Gauss, one of the greatest mathematicians of all time, once claimed: “mathematics is the queen of the sciences and number theory is the queen of mathematics”?

At the outset, numbers look straightforward enough, but interesting and sometimes surprising properties soon emerge naturally from their simple existence.

For instance, prime numbers emerge naturally. Primes are numbers which are only divisible (so as to yield whole division results) by themselves and by 1 (e.g., numbers such as 13, 17 or 3181), as opposed to numbers such as, say, 6 - which can be divided by 3 or 2 to yield a whole result. In turn, further results and theorems and questions emerge based on the existence of primes. One of these follow-on questions is the so-called Riemann hypothesis which is named after the mathematician Bernhard Riemann, a hugely difficult and as yet never solved problem (which has to do with the way prime numbers are distributed within the wider set of whole numbers. The Riemann hypothesis is one of the pending ‘millennium problems’: anyone solving it would immediately become eligible for a cash prize awarded by the Clay Mathematics Institute, and win a place in History. For a solid and very readable exposition of the problem, see Keith Devlin, 2002.)

Simple whole numbers naturally and inevitably lead to a whole ménagerie of other numbers - fractional numbers, irrational numbers, imaginary numbers, transcendental numbers, transfinite numbers, aleph numbers, beth numbers, and more. From a simple definition of one and two, a whole unexpectedly rich branch emerges, complex theorems arise, hugely complicated and as-yet unsolved conundrums crop up – which soon include side or meta questions which vastly exceed the narrow confines of pure number theory itself.

So far, attempts to answer questions about the nature of reality from an Aristotelian perspective have failed. Armed with a purely materialistic view, we don’t understand why delayed choice experiments work, we don’t understand why Bell’s theorem works
(which we will deal with in a moment), we don’t understand the Big Bang, and many other things beside.

Our toolkit therefore must be the alternative Platonic view, aided and enabled by pure math (10), with this we’ll now try and explore whether this approach can help us understand nature’s baffling phenomena – first and foremost the nature of Time itself. Abstract math is, at its core, just abstract numbers.

Keith Devlin, a mathematician at Stanford University, wrote his book ‘The Math Gene’ because of what he perceived as a deeply regrettable and unwarranted feeling on the part of many people that math is hard to learn. His book-length argument is that we are all potentially gifted mathematicians and only an undue lack of self-confidence, and/or bad and unimaginative, boring teaching can lead to the wrong but somewhat widespread impression that we’re not good at math.

Because of his enthusiasm for math, Dr. Devlin has become an evangelist, exploring novel ways to teach and communicate math to various audiences. It is easy to share his enthusiasm because math rewards any effort put into learning it. Of course, as in everything else, there is always the early, plodding phase of learning when we must walk unsteadily before we can run. It’s the same in everything; we can’t expect to just take up ice skating and immediately axel and glide gracefully in the rink, we can’t play a musical instrument after cursory practice, nor can we engage foreigners in stimulating foreign-language conversations after but a few hours of half-hearted, boring rote learning of stultifyingly dry grammar. Mathematics, like music and skating and everything else, will surprise us by just how not boring at all it eventually reveals itself to be, however, it demands that we first pay it a modicum of dues.

Many physicists are baffled by, as Nobel prize-winner physicist Eugene Wigner once put it, “mathematics’ unreasonable effectiveness in the natural sciences.” Stephen Hawking once asked “What is it that breathes fire into equations and makes a universe for them to describe?” to which Tegmark answers: “There is no fire-breathing required, since a mathematical structure is not a description of the universe - it is the universe.” He adds: “Everything in our world is purely mathematical - including you”.

Much earlier, Galileo Galilei had opined that “mathematics is the language with which God has written the universe.” This very feature of reality also seemed to also have stunned Einstein: nature scrupulously obeys abstract mathematical laws.

The effectiveness of mathematics in describing reality might, at first blush, seem totally obvious - after all, mathematics was first developed as a handy tool to describe nature and was derived from counting things which are ‘out there’. But math soon took on a life of its own and became more and more abstract. Mathematicians began to explore increasingly abstract worlds which soon opened up new unforeseen vistas, which in turn posed new questions and challenges and begot wholly new and unexpected landscapes of thought. These unearthed new unforeseen questions and challenges, led to rigorous and non-trivial abstract theorems dealing with wholly
abstract mathematical objects which are found to routinely establish unforeseen logical bridges to other branches of mathematics and even, as we shall see, physics and everyday applications.

The reason why pure math so often manages to describe the world, and even to foreshadow how and why it works the way it does (sometimes surprisingly so) is neither trivial nor obvious. But it goes even well beyond that: pure mathematics by itself seems to be in principle capable of creating material universes. As we shall see, the obedience or conformity of physical reality to abstract mathematics does manage to explain everything we care to look at in-depth – including how whole universes can be created from seemingly nothing, above and beyond, say, Shing Tung Yau’s geometry (11): a universe will pop into existence from nothing so that some valid applicable mathematical equation not be violated.

Mathematics has never been falsified: there is no known example of some valid mathematical equation predicting that something would happen and then somehow that something fails to happen.

Even particles - the fundamental constituents of all matter - are no longer described materially. The modern description of particles is purely mathematical – nature is now described in terms of fields. A ‘field’ is a zone in space where numbers are attached to the different points of that space. These numbers describe the values of certain properties at that point - a bit like, say, the space in front of and around a playing band or orchestra might be described by a sound volume field, with decibel numbers indicating the sound intensity attached at each point within the zone surrounding the band. The energy of a field is usually not continuous (it is ‘quantized’, which will be looked at shortly) and the quantum excitations of the field create the particles out of whole mathematical cloth (for instance, electrons are the quantum excitations of the electro-magnetic field, quarks the quantum excitations of the field associated with the strong force, and so on.) An even more modern view abolishes even the concepts of particles, fields, and quantum jumps altogether, to replace them by the effects of something called decoherence (we’ll be revisiting these concepts below).

The sun shines, or, broadly equivalently from a purely physics standpoint, an atomic bomb goes off, because of nature’s necessity to conform to what is the most famous equation of all time: \( e = mc^2 \) - and for no other known cause. There is no explosive within an A-bomb, at least not in the traditional sense of what an explosive is, but only a bit of matter (12): what explodes in an A-Bomb is a mere lump of matter (13). The blast only happens because matter conforms to \( e=mc^2 \) (14).

As it happens, the mathematical description of physical events and phenomena through equations routinely throws off extraneous terms. To attribute a physical reality to such terms is seldom straightforward.

\(E=mc^2\) is one such term, the leftover terms of the mathematical expression of the energy of a system when at rest. It is left over when all the speeds are set at zero in a calculation expressing the invariance of the laws of physics - the fact that they apply equally in different environments, or ‘frames of reference’. (In essence, in equations that say that the laws of physics and their
applicability do not change when circumstances and environments change. As an example, the laws governing, say, your body balance are the same irrespective of whether you are walking on a street, at rest in an airplane seat, on a moving bus or for that matter anywhere, whether at rest or not. The term \( e=mc^2 \) is a remnant from such a calculation.

If we accept math as sufficient on its own, as explaining a reality that will conform to it without a need for further explanations, then in one fell swoop apparent mysteries that still bedevil physics today become suddenly comprehensible. It explains physical laws that appear, from a purely material standpoint, baffling or incomprehensible, yet have been demonstrated time and again to be valid, sometimes spectacularly, as we’ll see.

‘Scalar’ fields, for instance - abstract fields made up of numbers associated with every point in space-time (15) - are invoked to explain a number of observed phenomena, but no one has necessarily much of a palpable in-depth understanding of the whys and wherefores of such fields, or of the mathematical operators (aka the equations of transformation) that hold sway within them. It just works beautifully mathematically, which is, most often, all that counts.

Thus, most tangible phenomena are now apprehended, or at least calculated, in terms of pure mathematics, reviving from a different angle a temptation on the part of professional scientists to ‘calculate and shut up’ (16): if mathematics is the sole reality, why bother and seek any further explanations? Reality is, there might just not be a deeper why and wherefore. Pure math might just be a sufficient explanation for the occurrence of any phenomenon, in which case it is not the physical phenomena but the associated pure math that must be looked at in depth. Even extremely recondite mathematics at the outer reaches of pure abstract thought - the kind of math found in Fields Medal (17) submissions, for instance - is routinely found to have totally unforeseen but tangible and immediate applications in physics and the real world (18). A discussion in an on-line research forum recently tried to find areas in pure abstract mathematics that would not have a practical application. It found none (19).

Bell’s theorem is one of the spectacular smoking guns, as it were, for the dominance of pure math over everything else. The theorem shows that something happening anywhere in the universe can affect instantly something else just anywhere in the universe, no matter how distant, provided that these two ‘somethings’ are mathematically correlated. We will look later on at a precise definition of what is meant by ‘correlated’ - how and why ‘somethings’ or ‘some things’ can become ‘correlated’, what it is that establishes a correlation. Unsurprisingly, this correlation comes about by the establishment, or prior existence of, a mathematical relationship between these ‘somethings’: their substantiated inclusion as variables within an equation called Schrödinger’s equation, named after the physicist Erwin Schrödinger.

How can such immediate effects occur over arbitrarily long distances, if no signal can ever travel faster than the finite speed of light? Can it be that the explanation is indeed purely mathematical and that the search for a non-mathematical explanation is futile and misguided – nothing but a reflection of cognitive biases favouring material
explanations because we evolved in a world macroscopically perceived by our limited senses as only material? If there is a purely mathematical structure underpinning the material structure of the world, perceiving that structure would afford zero survival advantage and it would hence be easy for a subconscious cognitive bias to develop against the useless awareness of such a structure.

Alternatively, isn't placing a math layer at the top of the reality hierarchy just a way to paper over our ignorance? We might just not know which arcane physical theory explains Bell's theorem, for instance, nor any other of the unaccounted real-world cases where math seems to dictate to physics, and hence to reality itself.

Notwithstanding, the physics community have tried, hard. Physical, 'material' explanations for Bell's theorem were sought – all the harder because the instantaneous, much faster than the speed of light, influence at a distance between correlated objects was repeatedly observed in the lab, repeatable at will. All the possible 'material' explanations failed:

- First, these explanations entailed extraordinarily contrived constructs and hard to believe baggage, all of it seeming furiously ad hoc. None of these scenarios are anywhere near proven or even provable.
- Another major issue is that none of the attempted explanations can explain any of the other smoking guns, all the other baffling phenomena we observe in external reality. Therefore, new ad hoc explanations have to be sought in every individual case, and some of these explanations are soon found to be incompatible with or even contradictory to earlier attempted explanations relating to the other phenomena for which a physical explanation was sought.

In some cases, looking for a physical reason would be tantamount to looking for so-called hidden variables - hidden variables which (here goes math again) are in most cases ruled out by something called Gleason's theorem, named after the mathematician Andrew Gleason. Moreover, even if for some reason Gleason's theorem did not apply in some exotic cases, it wouldn't help anyway: Renato Renner and Roger Colbeck in Zürich have convincingly demonstrated that no possible hidden variables hypothesis could possibly improve the significant outcomes produced by current theories. Thus, our search for a physical explanation fails. Some inescapable explanations lie squarely with pure math.

So we are seemingly left with a reality that just conforms to math, with at this time at least, no credible other option.

It could even be put more starkly. We could say that the equation (Schrödinger's equation) which makes Bell's theorem work - i.e., which predicts that two correlated 'things' are going to react instantly to changes affecting one of them across any arbitrarily long distance or expanse of space so that the equation binding them seamlessly continues to be valid - should be falsified by the laws of physics which mandate that nothing travels faster than light. But the incontrovertible fact remains that a status change initiated at an object located at a specific location in space is always proven to affect instantly another correlated object at another, arbitrarily
distant other location. We must therefore, at least provisionally, conclude that *math has falsified our physics*, not the other way around. Hence math sits, for the time being, squarely at the top of the pyramid.

Before we proceed, we must look at infinity - and infinities.