Turtles all the way down

When I saw the new essay contest announced I was very exited and could almost not wait to sit down and write an essay about how I think everything may work on a foundational basis. Finally an opportunity to describe for everybody how I think the reality is stitched together. But then I hesitated a bit, reread the question, read it again a couple of times and started thinking. What is really the question here? How to define what is fundamental? What are the properties of the truly fundamental? It is not that I've never gone down that road before but it is really easy to get hung up in details along the way and forget what we are asking for. And the question is really a clever one. While not a professional in physics, or philosophy for that matter, myself, I like to think about how things work on a fundamental level. But how to know that it is? Fundamental must be something that is impossible to divide into subparts, it should not require any prior framework and it must be possible to describe everything we know from it - no small feat indeed.
To start identifying what is what is truly fundamental I think one good rule of thumb is to start looking for the abundance of turtles.

"*Turtles all the way down" is an expression of the infinite regress problem in cosmology posed by the "unmoved mover" paradox. The saying alludes to the mythological idea of a World Turtle that supports the earth on its back. The phrase suggests that this turtle rests on the back of an even larger turtle, which itself is part of a column of increasingly large turtles that continues indefinitely (i.e., that it is "turtles all the way down"). The metaphor is also used as an example of the problem of infinite regress in epistemology to show that there is a necessary foundation to knowledge.* [Wikipedia]

And so, when we have ruled out infinite regression we should only need to locate the bottom turtle. Which sounds easy enough, but it has over the centuries proven quite elusive.
But why is it important to get rid of infinite regression in the first place? Could it not be that there really is something that goes on forever, always uncovering new details no matter how large the resolution is? The most obvious argument against this, is of course that it would be very difficult or impossible to answer the question in this essay contest. And that itself makes it an interesting target for dissection. What are the consequences of a reality that is of infinite resolution and is it at all possible to find anything fundamental if we can't locate the bottom turtle? One way to delve into that is to look at other promising candidates that may be fundamental. So lets take a small detour.

Another rule of thumb when breaking down what's fundamental is that it has to be background independent. Which means that we can't place it in a coordinate system or build upon properties like time. Location and time have to be emergent from the really fundamental building blocks. This unfortunately rules out a lot of explanations. Though, they don't have to be wrong, they just doesn't take into account the bottom turtle.
We know of course from observation that a lot of things are located in relation to other things - hence the compulsive craving for stuffing it in an orderly coordinate system - but to be compliant with the requirement for background independence the parts of the system have to know something about its neighbors. Or at least one neighbor. By following the connections between lumps of information we can suddenly say something about how they are related. So here we may have identified a candidate for a truly fundamental property: entanglement. Without information about how information is related, we wont have any structure and to build the universe we will need a lot of structure. This is a property that seems to be impossible to break down in sub-parts. And voila - we have a turtle. Maybe we should stop to regard entanglement as something weird, it may be one of the most fundamental things there is. But entanglement itself wont be enough to constitute a complete universe even though that property itself could make up a frozen image of any universe. Describing everything in a very fundamental and simple way could probably be done with vertices and edges and no value at each vertex. But I digress, lets look for other promising candidates for the fundamental.

If the universe is not a completely static structure, there has to be some functionality that can capture change. Aka - for example an edge that changes a vertex endpoint. But for these changes to have a impact there need to be some sort of structure. Just like the static information must be described by its relations, change also need some structure. So when a change happens

it will have some consequences. And that is what we usually call causality. So to have structured change, causality is the turtle of choice.

Is this enough to describe everything we observe around us? In my opinion - no, we have to insert something that makes the result not pre-determined. We need the element of chance. This touches the philosophical debate of whether it is possible to influence the future or if it is already predetermined. But I think both logic and observation speaks in favor of the need for randomness. Randomness also seems to fit well with our requirements for the truly fundamental.

So now we have defined the three turtles of reality - entanglement, causality and randomness. But we need a fourth ingredient to really set this on fire an that is to instigate causality or simply change. And the fourth slow rider of the apocalypse is of course energy. Or more precise - points of action that changes an endpoint and continue with the causality chain. The more action that can happen - the more energy.

An interesting twist to this way of viewing the reality is that location only has meaning as long as you're part of the dataset. And time - as the late Douglas Adams said - is an illusion. Or rather, it emerges from causality and is ,as location is, only meaningful if you're part of the dataset. Which brings us back to the concept mentioned earlier about there being turtles all the way down. Is this aforementioned dataset finite or infinite?

If we do accept these candidates as the truly fundamental, what would be the consequences of a reality with infinite resolution? Let's say we have a vertex A that is entangled with B which again is entangled with C. The rules for applying entanglement is of course open for discussion, but in the spirit of this essay contest we will try to find the simplest or most fundamental rule. So assume that a vertex N must be entangled with one other vertex that is not itself entangled with N and that each vertex only can have one incoming and one outgoing. A is then associated with C and could by a passing action point change it's endpoint to C. This forces, according to our chosen rules, C to change its end point. In this very small and simple universe all vertices have a nonzero chance of being entangled with any other vertex. So if we construct a universe with similar rules but infinitely many entangled vertices and action points. The nonzero chance of interacting with any other vertex becomes infinite. Should we choose a universe with infinite entangled vertices but finite action points, we will have a completely static universe because the amount of energy compared to vertices is zero. Causality will also get a shot in the bow if the causality chain will have to go by infinite vertices to get anywhere. Randomness on the other hand will probably do just fine.

So our quest to get rid of the infinite stack of turtles has been quite fruitful. And all we did was to see what happens when we try to define what is fundamental by nose diving into the problems brought forth by the devastating problem with infinities. And this is what the fundamental really is: a deconstruction of the system one is investigating. In other words the atomic parts that will suffice to explain the complete resulting system without requiring any background or any other prerequisites.

The really clever thing about finding or even looking for the fundamental is that it is possible to deduce a lot without direct observation. If the uncovered fundamentals is enough to describe everything we observe then it must be true. Of course until proven wrong by indirect observation. It may, if we're able to identify the correct fundamentals help us bridge the gap between what we do observe directly and the foundation of reality and I really think that entanglement, causality and randomness - with the addition of energy is a quite good shot.