Question 1:

Dear Cheap Astronomy – Is String Theory really a theory?

The mathematics underlying string theory involves finding mathematical solutions that effectively model the particles that either make up matter or mediate forces – that is, fermions or bosons. Those mathematical solutions are thought to be geometrical in nature and loosely model the motion of strings. String theory follows quantum principles, so only a limited set of frequencies are possible. So, a bit like how the strings of musical instruments produce musical notes when they vibrate within a certain set of frequencies, the limited set of allowed frequencies in string theory produce fermions and bosons.

Well that's idea anyway, no-one has actually cracked the code as yet. The fact that a lot of eminent people keep pursuing this line of enquiry suggests they really might be on to something. But, the answer to the question are we there yet, is definitely no.

It turns out that the mathematics of string theory will only work by invoking additional dimensions in which the various string vibrations required can take place. Current thinking is you need ten spatial dimension as well as time as the eleventh dimension. The additional dimensions required are invisible and unmeasurable, generally described as being compactified into such tiny spaces that they are undetectable. Critics of string theory suggest this is a case of the tail wagging the dog. That is, since the only way string theorists can get their math to work is to invoke invisible dimensions, they then claim that is how the Universe must be – possessing those dimensions, even though they haven't got their string mathematics to work yet.

We started this podcast with the intention of making another fantastic physics formula episode, but there isn't really one single string theory formula. String theory is a kind of sandpit that string theorists play in, where particular rules and principles apply – that are different from the rules that apply in other sandpits that other theorists play in. If you push a string theorist to show you the math that underlies their sandpit they'll most likely direct you to S-matrix or path integral mathematics, neither of which are really string theory and neither of which have single formulae either, they're just more sandpits.

To give you a sense of where string theory sits, here's a cheap summary of the current state of modern physics. Standard quantum theory does a fine job of modelling what point particles are, such as quarks, photons, electrons, mesons and so on. Quantum field theories also ably deal with particle interactions. Quantum chromodynamics describes how quarks are held together by gluons to produce matter particles like protons and neutrons. Then quantum electrodynamics models how light and matter interact, remembering that light is really electromagnetic radiation. But, we are yet to see quantum physics produce an effective explanation about how gravity works.

There are various quantum gravity theories out there – which are either just quantum gravity theories that try to apply quantum principles to explain gravity – or they are theories of everything that try to not only explains gravity but also explain electromagnetism and the weak and the strong nuclear forces and the underlying structure of matter – in other words, they pretty much try to explain everything.

So this is where string theory sits, it's a theory of quantum gravity and it's also a theory of everything, but at the end of the day it's a mathematical sand pit within which no-one has actually nailed a solution to anything yet – although they might one day

So, for the moment we generously call string theory a theory, but it's yet to fulfil its objective to provide one unified approach, let alone one formula, that effectively models the phenomenology of electrons and photons and gravitons – and that's assuming that gravitons even exist. String theory is best thought of as a theory with a small t, while General Relativity and Quantum Physics are big T theories, each supported by a truckload of observations and measurements.

Question 2:

Dear Cheap Astronomy – Is the future already determined?

Well, a bit, but mostly it's not. As we've argued before in CA, the only timeframe that exists is the present. The idea of hopping into a time machine and travelling to the past or the future assumes that both the past and future somehow exist as destinations. But there has to be energy available to sustain both your departure point, the present, and those destinations – past and future. However, from everything we observe in the Universe, it seems that all the energy available in the current moment of the Universe is consumed in taking it and us into the next moment. Otherwise you'd be constantly losing energy to sustain the past. So, it is pretty much a case of you can't have your cake and eat it. And similarly the future can't already exist now because all the energy currently in the present has to first be taken forward to power up that future.

Of course not everyone agrees with such a view point. For example, multiverse theories depend on the idea of there being sufficient energy to maintain multiple versions of the Universe simultaneously. Nonetheless, fundamental quantum mechanics offers some support for the future not being pre-determined since, at a quantum level, nothing is predictable – indeed everything is inherently unpredictable So, the future really is something that we make up as we go.

All that said though, we shouldn't talk about time in isolation. Time really is just one aspect of spacetime. So, while it may be true that the past is irretrievably gone, you can still it – indeed through astronomy you can still see 13.8 billion years of it. Anything that you see happening at a distance happened in the past – and whatever may be happening in that distance now, like today now, is as unknowable and inaccessible. You could travel to something a hundred light years away, but it will take you more than a hundred years to get there.

But, of course, anything becomes possible in science fiction, Star Fleet can receive an alert from the light years distant planet Vulcan about something that is happening now – like today now – because of sub-space communication, whatever the heck that is. And, according to Star Trek lore, Star Fleet can just warp over there to save the day and get home again in time for tea.

So it all kind of depends on what you want to believe. It's nice to imagine we have a Star Trek future to look forward to, but any by-the-book relativity theorist would say that receiving

information about what's happening on the light-years-distant Vulcan today – and then warping over there to fix it today, means you are seeing and accessing things that are outside of your light cone – i.e. you are seeing and accessing things today that are really in your distant, inaccessible and unknowable future.

Of course you can actually get yourself into the future by moving at close to the speed of light so that time dilation comes into play. So, if you fly around the Earth really, really fast, it might take you less than a day to get into the 23rd century. But all the while that you are doing that, everyone down on Earth can see you whizzing around and around overhead day as they live grow old and die. So, even though it might seem like you just clicked your fingers and went to the 23rd century, you actually went the long way around covering an enormous amount of distance while doing those orbits at very high speed.

So, that's our Cheap Astronomy proposition is that only the present exists. The past is gone, although records of what it was still come to us from the distant past by electromagnetic radiation and other means. The future is an undiscovered country that just hasn't happened yet and its form will be entirely determined by whatever template present moment gives it. So whatever actions or inactions we take now really do determine what our future will be. This is probably the most fundamental lesson that any sentient being, can and should learn – but boy, it's sure taking us a while.