Question 1:

Dear Cheap Astronomy – How big is the Universe?

Needless to say we just don't know, beyond saying it's at least as big as the observable Universe and very likely bigger. The real answer to the question may just be unknowable, since we will never see beyond the observable universe. To do that we would have to travel faster than light speed in a vacuum to get out to its edge - remembering that's an edge that's receding further from us faster than light.

One could argue that we are in a small corner of the Universe that looks like the observable Universe we see because it's the only region from which anyone could observe the universe, the rest of it actually being uninhabitable weirdness where strange geometries and physics operate. And as a consequence of that weirdness, stars and planets and ecosystems could never form and hence the unobservable universe is absolutely unobservable since nothing can survive in it to observe it.

That argument is perhaps irrefutable since we never will observe the parts of the Universe that are unobservable to us. But there are things about our observable Universe that gives some hints as to what the unobservable parts might be like. Everywhere we look in the observable Universe everything looks about the same, lots of galaxies of similar make-up, similar density and of a similar age range. So, it seems a bit unlikely that everything would suddenly change just beyond the edge of the observable Universe. Also, imagine another civilization that's say 1 billion light years to your left. If they looked left into a region of the Universe, that was beyond our observable sphere, but within theirs, it seems unlikely they would see a part of their Universe that looked thoroughly different to what they saw to their right.

So we might assume the isotropy – that is, the sameness that we see across the observable Universe also persists across the unobservable Universe. That's about all you can do – assume, but it's not an unreasonable assumption. Something else remarkable about the observable universe is that it's flat. Alexander Friedmann used Einstein's general relativity field equations to propose three possible universes – an open low density universe, a closed high density universe and a flat just-right density universe with no curvature. The way you tell which one you're in is to project out two straight lines of equal and known length forming two sides of an isosceles triangle, calculate the expected length of the third side with trigonometry and then measure the actual length of the third side through observation. If the observed length is the same as the expected length then you know you're living in a flat universe where Euclidean geometry applies and the three angles of a triangle add up to 180 degrees. And this is what we consistently find from observations to date – we live in a flat universe.

One school of thought here is that because the observable universe is flat the whole Universe must be hugely bigger, assuming it does have any kind of curvature. So we are like flat-Earthers assuming the Earth is flat just because our immediate surroundings look flat. But the other school of thought is that our observable universe is flat and the whole universe is just as flat, meaning you can't make any assumptions about how big the whole Universe might be. So if like our observable Universe, the rest of the Universe is isotropic and flat then we are back to having no clue how big it actually is.

The ultimate arbiter of the real size of the whole Universe may be early inflation – which remains a hypothesis, but does seem to tick a lot of boxes in explaining why our observable universe looks the way it does. Current thinking is that very early on spacetime popped out of a dimensionless nothing and proceeded inflating at a hyperbolic rate, creating the expanse we see as our observable universe – and potentially a whole lot more. There is a theory that inflation is still happening out there in a ever-widening volume, leaving spacetime behind in its wake, that spacetime then just expanding at the steadier rates we are familiar with. Or otherwise inflation just came and went in a split-second. Or maybe it lasted ten minutes – whatever way it happened has a significant bearing on how big the whole Universe is. Once again, we just don't know – at least, not yet.

Question 2:

Dear Cheap Astronomy – Are we really not going to Mars in the 2030s.

Well, probably not. NASA's moving target is now 2037, it was previously running with 2033 until an independent review looked at their current plan and said no way and also said no way to the next launch window in 2035, so it's 2037 now – which Cheap Astronomy guesses will be pushed into 2040 in about three years. China is still talking about launching astronauts to Mars in the 2033 launch window, but without a lot of details on how, excepting some hints that they might use nuclear technologies, at least for power if not propulsion.

NASA's 2037 plan is to launch astronauts from Earth in the Space Launch System/Orion capsule combo and then dock with the planned lunar gateway space station, where the crew will then transfer over to the DST, the Deep Space Transport vehicle which will take them to Mars and back The independent reviews main concern was that prototype testing of the DST needed start next year to make a 2033 launch. For China's proposed 2033 launch, it's possible their less-transparent space agency is already building lots of exciting new spacecraft behind closed doors, but that's just possible, not likely.

At this point in history, it's highly unlikely that any government or private company is going to invest the hundreds of billions of dollars required to get astronauts to Mars and back, when the chances of failure and crew mortality are as high as they currently are. Current propulsion technologies means a crewed Mars mission will take at least two years – and if you wanted to stay at Mars for more than a quick flag plant, it will be more like three years. Either way, two or three years is ample opportunity for all sorts of things to go wrong, on a mission where you have to take everything you need with you.

And apart from the mission infrastructure deteriorating over time, the astronauts health will also deteriorate under prolonged zero G and exposure to cosmic rays. There are theoretical solutions to these issues, but such solutions are barely on the drawing board, let alone flight-tested, and would require a radical departure from any spacecraft designs that are currently in production. Details are sketchy on NASA's Deep Space Transport vehicle, but it certainly won't have rotation-induced gravity. At the moment it's looking like an Orion capsule with a larger inflatable habitat module attached. It's assumed that the Mars-bound astronauts will get by much as ISS astronauts do, doing lots of exercise to counter the musculoskeletal and cardiovascular effects of zero-G, though that may not help with other effects of zero-G, for example its effect on vision.

The Cheap Astronomy research department couldn't find any details on enhanced-shielding options for the mission either. The standard Orion capsule has a radiation sensor, intended to detect a burst of increased radiation say from a solar flare. The crew are meant to then huddle together, surrounding themselves with stowage bags to create a makeshift shelter. There's talk of a more permanent emergency retreat compartment planned for the DST, but none of this thinking deals with the constant background flow of the generally-more-harmful galactic cosmic rays.

So, you have to wonder whether the agencies saying they will go to Mars in the 2030s really believe it themselves. NASA has a number of webpages covering a range of issues needed for a mission Mars that aren't obviously part of the 2037 mission plan. For example, using nuclear thermal propulsion and using nuclear fission generators to maintain power on the global dust-storm-prone Martian surface. These are good ideas that the Chinese may be considering also. Other even less talked about mission components are a Martian lander and the key issue of how it will carry sufficient fuel to manage both the landing and subsequent launch. Landing with its launch fuel on board looks like too much mass so sourcing fuel from Mars itself is being talked about as the best option available. So sure, we could go to Mars in the 2030s and maybe even land, whether we could take off again is an open question – as is what kind of shape the astronauts might be in at the end of such a mission. Of course, a lot of development can be achieved in 16 years, but only so much.