Question 1:

Dear Cheap Astronomy – Did the Universe start from a single point?

This hypothetical concept is commonly stated in pop science blogs and we are guilty of doing the same here at Cheap Astronomy. However, it's not necessarily correct. As with most things relating to the Universe, all we can really talk about is the observable Universe. All evidence available does suggest that it emerged from a point source 13.8 billion years ago, but if the actual Universe is bigger than the observable Universe – and it very likely is – then it's not clear that the whole Universe emerged from that point source.

It could have, if in some fraction of the first second, inflation pushed out lots of proto-Universe into distances that we neither can nor will ever be able to observe. This gives some credence to a belief that the unobservable Universe could be similar in nature and consistency to our observable Universe, which is very homogenous and samey up to the limits of our observation. But it is best just to call that a belief. There's no way to confirm anything we may choose to assume about the unobservable universe since any observational data about it is out of our reach.

Nonetheless, it's probably fair to say that the consensus working model is that the observable and unobservable Universe did emerge from the same point source 13.8 billion years ago. No-one's disproved it yet, so it's what we are choosing to run with for now. The idea of the Universe appearing out of nowhere seems extraordinary, but it is perhaps a more satisfactory idea than the idea that the Universe has just been around for all eternity. Things should have beginnings – and when you are talking about the beginning of everything, it does makes sense that before there was everything or anything, there must have been nothing. What else could everything have started from?

But as to a causal mechanism, hoeee, that's a long way off still. Current thinking varies widely, but for example, it might be the case that potential universes pop out of nowhere on a regular basis and last for varying durations – all assuming that each such pop of a potential universe involves a rapid expansion of spacetime meaning that each will have a certain size and duration.

We could also assume that each of those initial pops of spacetime contain a stupendous amount of energy, which then begins to cool as the spacetime that contains it expands. The precise nature of this energy is not clear, we are just saying energy in air quotes. Whatever it may be, things begin to freeze out of it as it cools. So you get leptons, such as electrons and neutrinos, and then you get quarks - which towards the end of the first second mostly coalesce into protons and neutrons, and presumably you also get dark matter – which is whatever it is. So what was just energy at a constant temperature becomes a mix of mass and energy and a degree of clumping of particles with mass begins to appear as the temperature keeps falling because the Universe keeps expanding.

At least that's a story that fits our Universe, lots of other Universes may have different stories. One thing that bothers everyone is that our Universe should have equal amounts of matter and antimatter, but at some early point matter came to dominate. There's no consensus view on how or why this happened. It does perhaps raise the possibility that while Universes may pop out of nothing on a regular basis, their balanced anti and non-anti contents then self-annihilate. You only lose charged particles in this way, but that means you lose protons and electrons – so no stars, planets or people. But since we know an imbalanced Universe has happened once and we don't know of any other Universes, imbalanced Universes may be more the norm than the exception. As to why ours and maybe other universes pop out of nothingness, that remains an unknown, The best we can say, on the basis of the very limited evidence available is that if things can happen then they will at some point happen.

Question 2:

Dear Cheap Astronomy – Is spaced based solar power the solution to all our problems?

Well, not all our problems and while SBSP is technically feasible, it may not be economically viable. The general idea of SBSP is that you have a solar collecting facility in Earth orbit, which then transmits the energy collected as microwaves down to the Earth's surface. Microwaves are preferred since they pass through the Earth's atmosphere relatively well and should not harm aircraft, ground infrastructure or people if they happen to get in the way. It might seem a bit daft to intercept light that already passes through the Earth's atmosphere, convert it into a lower energy form of light and then pass that through the atmosphere. However, the collection of solar energy in space has a lot of advantages over ground collection. Firstly, passage through the atmosphere scatters sunlight and higher energy wavelengths in the ultraviolet just bounce of it. So a solar panel in space can generate two or three times more power than an equivalent panel on the Earth's surface. Also you can collect solar energy in space for nearly 24 hours a day. Assuming your collector is in geosynchronous orbit at nearly 36,000 kilometres altitude, Earth will rarely be directly between it and the Sun so you can keep your collector illuminated for an average 99% of the time over the course of a full year.

So, that all sounds great, but now here's the downsides. Since we are talking about a microwave beam with a lower intensity that sunlight, you'll need a wide beam to transmit a worthwhile amount of power to the surface - a transmitter aperture of around one kilometre in diameter is suggested. Then, since you are sending the one kilometre diameter microwave beam across a distance of 36,000 kilometres, with the last 10,000 kilometres being through the Earth's atmosphere, the beam will spread, so you need a much bigger receiving aperture on the surface, perhaps ten kilometres in diameter. That's some pretty serious infrastructure requirements, involving a substantial upfront investment, not to mention public opinion challenges around fears of a death ray, plus no-one really wanting a ten kilometre wide microwave receiver in their backyard. So, this is where we say it's technically feasible, but economically problematic. And the biggest problems actually lie with the one kilometre space transmitter rather than the 10 kilometre receiver on earth. Firstly, it's a lot of mass to launch and get all the way out to geosynchronous orbit and it's also a lot of infrastructure to maintain there.

In geosynchronous orbit, above the magnetosphere, solar panels surfaces are quickly degraded by the solar wind and micrometeor strikes on one kilometre diameter surface area are going to be inevitable if not frequent.

Also you are dealing with something built to maximally-capture radiation, which is hence going to get quite hot and there’s an inverse relationship between solar panel efficiency and how hot they are. You can deal with that by adding a cooling system, but really that will just be a heat transfer system, so you’d still have to get rid of the heat somewhere, perhaps through large surface area radiator panels – so that’s more mass, more structural complexity and more points of failure.

In January 2023, Caltech’s Space Solar Power Demonstrator was launched into low Earth orbit aboard a Space X Falcon 9 rocket. The small satellite did demonstrate that lightweight small-scale components of a SPSB could work in space and the unit did transmit a tiny microwave signal back to Earth. So, this confirms the technical feasibility, but the next step of scaling it up to an meaningfully productive and economically viable system is where all the question marks lie. The infrastructure and maintenance requirements look to be hugely expensive and a cost-benefit analysis is difficult to undertake until we actually implement something.

So, we’re not meaning to write the whole thing off as a bad idea, but the cost and uncertainties involved in implementing a working system mean that it’s not going to happen any time soon. There is a commitment from several government agencies to further develop small-scale trials and tests, which is probably the best way forward for now.