Question 1:

Dear Cheap Astronomy – Could you really grow plants on the Moon or Mars, without shipping in lots of nutrients.

This question is really about whether you could ship in a base load of nutrients that would be adequate to sustain a long term ecosystem in space that effectively-cycled all the key nutrients needed to keep plants alive.

So, the first essential factor for plant growth is liquid water – and to have liquid water, you firstly need a stable temperature range where it will neither freeze nor boil away – and you also need a certain atmospheric pressure or the water will just boil away anyway – and you also need a certain atmospheric humidity or the water will slowly evaporate away.

From there, you then need the other ingredients of photosynthesis – which are carbon dioxide and light. And, although plants do produce oxygen as a by-product of photosynthesis – you will need the atmosphere that the plants are growing in to already have a partial pressure of oxygen that's similar to the Earth's. Even though green parts of plants can produce their own oxygen under light, they still have to survive through the night, and any crop plants will need oxygen-aerated soil all day long in order to keep their roots alive.

So, before we even get to the nutrients, you can see that if we're going to grow plants in space – we'll need to grow them in a pressure-sealed, temperature-regulated and humidified enclosure. And you'll probably also need some artificial lighting. Natural light on the Moon is problematic – it's great light for two weeks, but then you get total darkness for two weeks, which would not be conducive to productive growth and play havoc with their diurnally-regulated hormone systems that drive flowering and fruiting. The natural light on Mars would be better for diurnal regularity, but Mars only receives about 60% of the Earth's average solar flux – so that would mean low productivity anyway.

But OK, let's now think about the nutrients. Plants need nitrogen to build proteins and chlorophyll and phosphorus to build nucleic acids. Calcium, magnesium and sulphur are also needed to build various specialised molecules that are used in plant structure and metabolism. And there's also potassium – and probably also sodium – which aren't so involved in biochemistry, but are vital for maintaining a plant's fluid balance and various osmotic pumping mechanisms.

After that, you have the micronutrients – the lack of which might not kill plants outright, but their absence will impact on productivity and growth and could eventually kill them. The principal micronutrients are iron, boron, molybdenum, copper, zinc, manganese and chlorine.

So, to create a sustainable ecosystem in space, suitable to grow crops, you first need to grapple with the engineering issues involved in creating an adequately-pressurised, heated, humidified and lighted growing environment. With sufficient solar flux, solar panels and storage batteries you could certainly power such a system, but it's still going to need constant maintenance and a regular supply of spare parts, which are either managed by humans or a team of clever robots, much cleverer than any we are able to build today. Look out for a movie called Silent Running if you want some examples.

As for cycling nutrients, sure if you start with a batch of plants in fertile soil and their life cycles are short, you might be able to keep the soil replenished, as those plants live, absorb nutrients from the soil and then die, but breaking down deceased plant material and to return nutrients to the soil really requires fungi and bacteria. And you'll probably need earthworms for further processing and of course to keep the soil well-mixed and aerated, So, there has to be enough constant cycling of plant material to feed and sustain populations of such partner organisms . And, of course, the plants will need to be pollinated to produce future generations, which means insects – if not birds and even mammals. In a nutshell, it takes an ecosystem to raise a potato – or otherwise it needs the intervention of a human farmer (or a clever robot) to manage the entire life cycle of a plant and maintain its soil. And, of course, humans are also useful at producing fresh carbon dioxide, not to mention fertiliser.

Question 2:

Dear Cheap Astronomy – Is there much chance of us dying, from a near-Earth asteroid impact, or Nibiru – or whatever?

Well, as usual, the end is not nigh. So far, life on Earth has survived a 4 billion year journey from a warm little pond to enjoying pina coladas at a pool-side bar, so it seems unlikely the whole show is going to be snuffed out on some arbitrary date that someone found in an old book.

Of course, bad things happen – like to the poor old dinosaurs, although the birds and indeed the mammals did quite well out of that. The mass extinctions that we know about involved multicellular organisms that left a fossil record behind – although one of the first and maybe biggest mass extinctions of all was the Great Oxygenation Event about 2.5 billion years ago – where the development of photosynthesis suddenly added lots of molecular oxygen (O_2) to the atmosphere and the oceans. Since oxygen is generally toxic to anaerobic organisms it's assumed that many such species quickly died off and in vast numbers around that time.

The earliest mass extinction we find in the fossil record was the end-Ordovician era, 450 million years ago which might have been due to the sudden uplift of a huge mountain range with a huge surface area of new rock that sucked a lot of CO_2 out of the atmosphere and caused a snap ice age. Then there was the end-Devonian event at 375 million years ago which took out the trilobites. This might have been because of a sudden deoxygenation of the oceans due to the first land plants stirring up nutrients which then washed into the oceans, creating huge algal blooms. The end-Permian event 225 million ago was probably the most-devastating of the lot – resulting from massive volcanic activity around the Siberian traps, which added lots of CO_2 to the atmosphere and also stimulated methanogenic bacteria to add methane to the atmosphere – and so massive global warming resulted, as well as a lot of anaerobic toxins being added to the oceans.

The end-Triassic extinction 200 million years ago cleared the stage for the dinosaurs, but its cause is much debated – possibly an asteroid impact or a volcanic event, leading to sudden climate change but no-one is really sure. And then there's the end-Cretaceous event which definitely involved an asteroid impact, at Chicxulub, although parallel volcanic activity from the Deccan traps may have already been putting pressure on ecosystems beforehand.

And right now we are arguably undergoing the Holocene (or the Anthropocene) extinction, which is happening because of humans and so it's a bit about climate change, but it's also about destroying whole ecosystems, eating megafauna as well as just killing them so as to do bizarre things with their body parts – and of course there's all that plastic and shit we dump in the oceans.

So, it turns out that extinction events are often caused or facilitated by life itself – rather than just by random planetary or astronomical factors. In fact, there may have been some major asteroid impacts that didn't have much effect on life at all. We think something major happened around 800,000 years ago because of the Australasian strewn field – which is literally a field of objects strewn all over Australia, south-east Asia and parts of southern China. These objects are called tektites, which are molten rocks that have been aerodynamically-shaped. Tektite mineralogy is clearly not of volcanic origin and so is most-likely melted crustal rock that's been thrown up by an impact. That molten rock is then cooled and solidified after following a parabolic trajectory through the atmosphere.

The fact that lots of chemically-similar tektites of the same age are found over such a huge area of Earth suggests it must have been a pretty big impact, but no major dying-off of species occurred at that time. Indeed, at that time, Homo Erectus was making its way through the region and sites in China have found stone tools and tektites in the same location, seemingly deposited at the same time. So it seems there was a major impact event that may have started a few forest fires here and there but otherwise didn't disrupt things all that much. We are yet to determine the location of the crater from where all the Australasian strewn field debris came from – a site in Laos or another in Vietnam have been suggested.

But anyway, despite all the death and mayhem of the past, our own species is doing just fine thanks-very-much. We have now assessed the neighbourhood and found nothing of the mass-extinction variety that's heading straight for us. Indeed we have been scanning the skies for last 400 hundred years now – so the idea of a rogue planet suddenly sneaking up on us, out of nowhere, is kind-of absurd. And despite all the death and mayhem we are now causing, we are gearing up towards creating the first opportunity to get the DNA replication system off the planet – something which has been 4 billion years in the making, but may eventually lead to life persisting long after our home planet is swallowed up by its dying Sun.