Question 1:

Dear Cheap Astronomy – What will first contact really be like?

Having never had contact with aliens, humans are want to speculate wildly on how, when and where it might happen. Here at Cheap Astronomy, we do cover this area regularly and here are our conclusions to date.

Firstly, given relativity it looks unlikely that any future technological advancement will ever enable faster than light travel or faster than light communication. So with likely travel times of hundreds or thousands or years, it's hard to imagine humans choosing to lock themselves up in a cramped spaceship for a lifetime and doom their children and grandchildren to the same fate for the sake of reaching a destination centuries or millennia later that is unlikely to closely-match Earth with respect to atmosphere, gravity or stellar radiation. Hopefully it will have water, but finding an ecosystem with edible organisms that can deliver all our nutritional requirements seems highly unlikely. So, we can't just go with enough food to sustain us, we need to take the makings of a sustainable ecosystem. Sure, you can take lots of vitamin pills with you, but they have a shelf life. So, a range of crop plants and perhaps some insect-based protein sources seem essential. Taking macrofauna like cows and chickens would be energy and volume inefficient and carries disease risks, although some kind of cultured lab meat might be an option.

But even assuming you have enough food and water, your survival also depends on lots of key systems not breaking down over hundreds or thousands of years, with no hope of calling in a repair person or buying spare parts. There's also radiation and collision risks to deal with.

Of course we might meet aliens by them coming to us, but they face all the same issues – even if being alien makes it different. They might be colony creatures, where the comfort or survival of individuals isn't an issue. Or their life spans might be very different, where a very short or very long lifespan might mean that sitting in a tin can for hundreds or thousands of years isn't that big a deal. But it would still take a lot of energy and resources to come here and it's not like after they arrive they can then just sit down for a chat over coffee and croissants.

So we might be better trying to communicate with electromagnetic radiation, but there's still that matter of the speed of light meaning that any discussion between stellar systems a hundred light years apart has hundred year pauses in between. Again, this may not bother the aliens even if it drives us crazy, and after a couple of centuries of exchanging carefully curated lists of questions we might both gain quite a lot of knowledge, at least for our grandchildren

A third alternative is that we just send our respective robots – presumably with advanced AI capabilities so they don't have to wait to get instructions from back home when different decisions are required. It's not particularly likely the robots will want or need to meet in person but by gaining some proximity they could exchange information in close to real time, perhaps comparing notes about their respective progenitor species, as well as asking a set of curated questions they brought along. That mutual exchange in close to real time would cut out a lot of toing and froing between the distant civilizations. And after their close exchange the robots

could phone home their respective findings, which might include photos of their new surroundings and their new associates. It's unlikely our robots would be humanoid and theirs would be whatever-oid. More likely both would be just be computerized spacecraft, but a look at each other's technologies would no doubt be instructive.

This all assumes a degree of benevolence or willingness to share, which is often a fleeting part our nature and may not be any part of theirs, But hopefully some logic exists on both sides, where killing each other won't achieve anything, So sharing might be primarily motivated by the desire for self-gain, which does seem the most likely factor that all living beings will have in common.

Question 2:

Dear Cheap Astronomy – What are Closed Ecological Life Support Systems?

A recent episode raised the necessity for sustainable life support systems in long duration space voyages where resupply isn't really an option. The basic principle is to recycle everything, something that is relatively straightforward insofar as water and carbon dioxide can be turned into carbohydrates and oxygen by photosynthesis and then those carbohydrates and oxygen can feed a metabolising organism which produces water and carbon dioxide as waste products. Things get more complicated when you add more biochemistry that builds proteins and fats as well as carbohydrates. But then it's a case of one organism composed of carbohydrates, proteins and fats getting eaten by another organism to build up its own body of carbohydrates, proteins and fats and ultimately its waste products return to the soil, feeding worms and ultimately fertilising the plants that underlie the whole ecosystem. All you really need is an input of energy and the raw materials that get recycled.

Currently we do have water recycling on the International Space Station. And we are growing some plants up there too – certainly not enough to absorb all the crew's exhaled CO2 but that's just a matter of scaling. Both the water recycling and the plants need energy – generated from the ISSs solar panels which power both grow lights and the water recycling plant.

But taking this to the extreme of a generational ship that's on a thousand-year journey between stellar systems you not only need energy and raw materials, you also need meticulous planning. Of course, before we go there we have to assume the ship has a thousand-year energy source on board since there will be minimal starlight available across the void between star systems. This is a pretty huge assumption, but if we just hand-wave past that and assume there is unlimited energy for grow lights and recycling machines, then you could build a closed ecosystem based on crop plants in greenhouses. Here you would likely also go down the genetic modification route as well, ensuring you have plants that deliver high yields and with added genes to allow the plants to also make the vitamins we need.

To get more protein and diversity you could add a fish farm, where you could convert different organic waste products into fish food. Or if there are volume restrictions you could have an insect farm instead, where for example freeze-dried crickets apparently make a good protein-

rich flour. And if volume is really limited, you could just grow algae and fungi, where the algae would use grow lights and fertilizer and fungi would grow on other organic waste – and the end product of these would be something like Soylent Green. And yes, it would be people - wherever we've said fertilizer and organic waste above we are including people, ripe old-aged, assisted-dying people.

So, this may all sound feasible, but running a genuine closed ecological life support system that has to operate over a millennia with no chance of resupply means you have to keep all the nutrients cycling through the system and maintain a very fine balance of inputs and outputs. So not only do dead people need to be recycled but no-one should have a child until someone else dies or you'll risk running out of food. Alternatively, if you have a number of deaths all at once, you may have to lose some plants because there's not enough CO2 being exhaled to keep the plants going. And when you lose a few plants, there's less oxygen being produced. So, you can't necessarily have more kids later on to compensate for a run of sudden deaths, because the ecosystem would have shrunk in the interim. You might manage to get around all that by having stored oxygen and CO2, not to mention stored seeds and frozen embryos. But it is likely there's a degree of entropy-related inevitability in seeing the capacity of your closed system declining over time - just because a perfect balance can't be maintained indefinitely. So, in the absence of new inputs, a closed ecosystem will inevitably shrink.