Question 1:

Dear Cheap Astronomy – How will we build a lunar colony – Part 1

Everyone seems convinced we're going to do it, sound economic basis or not, so let's look at some of the practicalities we need to deal with. Firstly, no atmosphere – and we don't just mean the ambience. Apart from the obvious problem that you can't breathe, you also have issues with the lack of atmospheric pressure. So you can't just walk around with an oxygen mask, because gases dissolved in your blood under Earth's atmospheric pressure will boil out and you'll die in agony from an extreme case of the bends.

Even with a pressure suit on, having no atmosphere means it's hot in sunlight but freezing cold in shadow and of course once the Sun sets you have two whole weeks of freezing cold. The Apollo astronauts all landed in the lunar day so most of their issues involved keeping cool, since with no atmosphere it's also hard to lose heat – no cooling breezes, indeed no convection at all, except through your feet. All you can do is slowly radiate heat away, which won't be a net loss if you are in sunlight.

One very effective solution is sublimation, where water exposed to a vacuum immediately evaporates. This process is so effective at removing heat that any remaining water then freezes – which is a problem because that then stops any further flow of liquid water to the sublimation interface. The engineering solution to that was a sublimator plate – essentially a metal plate with tiny pores through which water can flow. When you expose the plate to a vacuum, there is sublimation until the water freezes within the plate, but if you also run warmed water past the inside of the plate that will unfreeze the water within the plate, allowing another sublimation step.

So, the sublimation process speeds up the more warmed water is run past the inside of the plate so it ends up being a self-regulating process – the warmer the inside is the more heat loss occurs to the outside. The flat geometry of the plate means lots of surface area is exposed to vacuum and the tiny pores are helpful since the repeated expansion and contraction due to the water freezing and unfreezing would quickly destroy any larger bore tubing. As it is, sublimation plates have a short functional lifetime and need to be replaced regularly.

For the most part, it is easier to keep astronauts warm than to cool them down, so space suits are routinely white as a first step in minimizing heat absorption. Then water is pumped through a network of tubing that runs through a full body garment worn by the astronaut and that warmed water is cooled down again by running it past a sublimator.

Similar issues must be considered in building habitats for lunar colonists. First they have to be sealed and pressurized and then they also have to be cooled since you will not only have people within them but also machinery and computers and eventually people are going to want to have warm showers and cook and maybe even have dance parties. With all that going on, even in the lunar night a busy habitat will need more cooling than heating. With a fixed structure, you can rely more on large surface area radiator panels that water will circulate through, just cooling the water rather than freezing it, so you can reclaim all that water again. In a one hour

spacewalk, an astronaut's space suit might lose a litre of water to the surrounding vacuum from sublimation cooling.

And of course, water is a big deal. If we don't first suffocate, freeze or overheat, dehydration will be the next thing to kill us. Water is abundant on Earth, but expensive to lift off it, so we have high hopes of finding enough water for our needs in situ on the Moon. We have particularly high hopes of finding big chunks of water ice in shadowed craters around the poles. If we don't, there are a range of hydrated minerals in rock and regolith we could feasibly extract water from, though whether you can gather enough from your immediate surrounds to meet the needs of a colony is yet to be established. And then of course we've got to eat. So to deal with all that – yep, we're going to need a Part 2.

Question 2:

Dear Cheap Astronomy – How will we build a lunar colony – Part 2

In the previous episode we considered that in a lunar colony you're going to want to breathe and be in about 1 atmosphere of pressure and have regulated temperature, which ends up being mostly about keeping cool. And you'll want to eat and drink too.

Of course all that requires energy. Solar energy is there in abundance since there will never be any clouds, but remember you're dealing with 2 week long lunar days and then two week long nights. You could probably get by with large banks of batteries to get through the nights, but current thinking is we'll start small by settling at one of the poles, probably the South one. It has more craters than the North, which are good because the shadowed depths may have lots of water ice, while the crests may get permanent sunlight and hence be good places to set up solar panels. In the long-term, we might look at nuclear fission reactors and if we ever crack nuclear fusion and can build one on the Moon there is a ready supply of helium-3 in surface regolith. For either fission or fusion managing temperature regulation in a vacuum will be a major issue, or otherwise the reactors could quite literally melt-down.

At the end of the day, building and maintaining anything on the Moon is feasible if it's economically viable to ship materials from Earth, but that is a very big if. We appeal to lots of potentials for doing as much as possible in situ to reduce reliance on shipping. So we can make concrete blocks and mortar from regolith and build dry stone walls from rocks that matter, but if we're going to have pressurized habitats we'll need metals and plastics from home. In the longer-term we might extract aluminium from lunar soil, but first you have to build an aluminium smelter.. As with many in situ resource utilization ideas, you first need the infrastructure. So, there's no point thinking you can found a colony on such ideas. To start with, we'll just do what we can with water ice and regolith. Everything else will be shipped in.

That said, we could start growing food, given the abundance of sunlight available. In the early days, it's unlikely this will achieve more than supplementing supplies from Earth and the focus will be mostly on low volume, high productivity outputs, since everything will have to be grown in Earth-equivalent atmosphere and using precious water – so algae, fungi and insects may be staples on the menu, but hopefully some potatoes and soybeans as well.

If lunar tourism ever takes off, there might be demand for more sophisticated dining – but you have to wonder why lunar tourism would ever take off. In the early days, lunar tourism might have an equivalent appeal to say climbing Mt Everest – which attracts around 7,000 climbers a year and is both very expensive and dangerous. In the longer term, lunar tourism might become less dangerous and economies of scale might make it cheaper, which would then make it more like Antarctica, which attracts around 125,000 tourists a year, although Antarctica does have penguins – and you can breathe. For comparison, ten million tourists a year visit the Hawaii archipelago, which is a remote location you can only fly in and out of, or catch a cruise ship, but not only can you breathe, but also swim, surf and stay in hotels.

This brings us back to the point that sure you can overcome all sorts of technological issues to colonise the Moon, but first there's got to be some kind of economic rationale to drive all the investment required. So, it could be a great place for astronomical research, particularly on the far side, or it could be a transit stop for interplanetary missions, assuming we find an economic rationale for doing lots of interplanetary missions, or it could just be an outpost for general scientific research like the International Space Station. None of those options really spell colony, but they are a foothold. What happens after that requires an as-yet unanticipated development. So maybe it will turn out that crashing asteroids on the Moon for mining purposes is actually a good idea or maybe we will find some other use for an orbiting platform of magnificent desolation that no-one has conceived of yet.