Question 1:

Dear Cheap Astronomy – Does life arise from extremophiles or do extremophiles arise from life?

It's often claimed that life could arise from simply anywhere since, hey, look at extremophiles that can survive in nuclear reactors, on the external parts of orbital spacecraft and in various highly saline, hot, caustic or otherwise downright inhospitable environments. While true, it's unclear whether such organisms arose in such unfriendly environments or whether life on Earth might have begun in one of Charles Darwin's imagined warm little ponds and then evolved and expanded its reach into more hostile environments.

That expansion was mostly driven by competition for resources – since, today, the only things that live in warm little pods are highly efficient, niche-exploiting powerhouses that can out do the competition – at least until the competition comes up with something new. Any less efficient organisms were long ago cast out to try and eke out a living in the colder and harsher world outside the pond. Their first attempts may have failed, but the reproductive organisms within the warm little pond would have kept on pushing out new variants until some eventually managed to gain a solid foothold a few centimeters outside of the pond. It's them that were the very first extremophiles.

In reality, not many evolutionary biologists still go along with the warm little pond concept. The current favored theory is that life arose in the oceans- and perhaps around hydrothermal vents. Another current theory is that life did involve on land – or at least under-land, perhaps a kilometer or more down, where the environment was warm, but still a tiny bit wet. In either scenario, those originating life forms were protected from dry land surface radiation, which would have been pretty fierce in the absence of an ozone layer. It's thought that it's only when photosynthetic life took off and began adding oxygen to the life starts in a stable, warm and bio friendly environment within which its primitive denizens have time to develop the capacity to both live and reproduce and to also survive unanticipated changes in the environment – and once you have those basics sorted out you might then start widening your range into new territories.

So that is the point that we're trying to make here. Mother Earth supported the establishment of many complex and intricate intracellular mechanisms that allow Archaea, bacteria and eucaryotes to survive. The large majority of life's biochemical complexity involves enabling a single cell to survive and reproduce. The subsequent step of building multicellular bodies isn't as difficult, although keeping those bodies intact and functioning is a different kind of challenge – humans and mammals generally has solved that problem by turning ourselves in walking warm little ponds. But now consider the humble tardigrade – which can astound us all by going into metabolic status and survive for long periods in the harsh vacuum of space. But stasis is stasis, if a tardigrade is to grow and to reproduce it needs to be returned to its native environment – a clump of wet moss, which is to all intents and purposes, a warm little pond.

So the idea that because extremophiles manage to cling on in the face of adversity therefore means that life can just evolve anywhere, may not be a reasonable conclusion to draw. Earth's extremophiles cling on in around the edge of the envelope of what is otherwise a rich, warm energetic and highly bio friendly centre. The extremophiles who have got farthest

away from Earth and remained active, even if they didn't actually reproduce, are of course the humans. We took a whole bunch of E Coli bacteria and a range of other gut flora along with us, as well as some demodex mites on our skin, but the effort and determination to achieve the goal was totally us. We also crash-landed a bunch of tardigrades on the Moon last year, but no-one is expecting them to survive, let alone flourish – a few might have managed to hang on in stasis for a while, but there's no talk of a rescue mission so give it a decade or two and they all be gone. So, extremophiles – meh. We are the real extremophiles, indeed the next evolutionary step, when we build self-replicating robots, who'll be the real extremophiles who will go out and conquer the Universe – but hopefully let us cling on to our warm little ponds back home.

Question 2:

Dear Cheap Astronomy – Will we have pets in space?

So, firstly while having a pet in space might be a good thing for the owner, it's also important to consider whether it's going to be good for the pet. Our moral history in this area isn't great, where we sent Laika into space with no possibility of returning her to Earth and she ended up dying from overheating before the plan to feed her suicide pills was enacted. Despite best efforts, it's currently the case that the health of human beings deteriorates after long periods in microgravity and it's pretty clear that most animals would suffer in a similar way.

The mental health of animals would also be an issue where they might eventually adapt to microgravity, but are likely to freak out in the first instance. Being us, we've done lots of experiments flying various animals in planes that fly on parabolic trajectories to create a microgravity environment. We found that cats freaked out because they keep trying to orientate themselves to land on their feet. Pigeons were unable to fly – that is they floated around, aimlessly flapping their wings, but not really flying. Apparently gravity provides them with an up-down orientation they need to fly in a straight-line. And yes we've even done snakes on a plane where the snakes seem to lose their sense of physical self and start attacking their own body as though it's an enemy snake. In the space station era we also found that butterflies couldn't fly and some hatched baby birds had to be put down because they couldn't figure out how to eat, perhaps being born with the expectation that bird-seed should stay on the ground.

So, all in all, life in microgravity would probably not be a great experience for either a pet or its owner. Fish might be your best bet for a zero-g pet – although oxygenating and cleaning their sealed tank requires some clever engineering and even they lose some bone density since water pressure doesn't increase with depth. But put gravity back in picture and the outlook is better. Assuming we do eventually establish permanent bases on the Moon or Mars, pets seem a likely addition once life within such bases settles into a routine. Similarly, a colony ship using rotation to create artificial gravity could also work for pets. It might not be a walk in the park for dogs – who, you know, enjoy a walk in the park – but it might be OK for your average cat, who'll sleep most of the day and probably prowl at night hunting for the mice that are likely to eventually find their way in via a food shipment or something. And with

gravity, fish would also be fine and wouldn't need a special tank – and rabbits, guinea pigs and even snakes would probably be OK too.

Of course all this awaits future technologies and bulk transport carriers that provide enough economies of scale to allow us to do somewhat frivolous things like take pets along with us. There maybe some cost-saving options such as launching eggs and sperm, but for mammals at least, having a parent may be a necessity at least in the first weeks – so transporting eggs and sperm maybe more about maintaining genetic diversity in an off-world breeding population rather about growing anything from scratch.

And maybe future technologies will include robopets. It is mostly the case that we like dogs and cats because we've bred them to be likeable. We may get a closer match to what's likeable if we build something from scratch with that particular purpose in mind. Given what we did through breeding cats and dogs, the ideal robopet is probably something which appeals to our general liking for cuteness and companionship and the ideal robopet will be something that has sufficient predictive algorithms to know precisely when we want interaction and when we don't – and what type of interaction we might want when we want it. In the face of that, there may be a few die hards who will still favour the old-fashioned bred-for-purpose companion animal – but it's not clear who will have the moral high ground there. Is it better to have a relationship with a biological entity that's been genetically manipulated to unconditionally like you or is it better to build yourself a plastic pal who's fun to be with.