Question 1:

Dear Cheap Astronomy – How low can you go and still maintain an orbit?

Assuming planets were perfectly inelastic spheres with no atmosphere then there'd be no hypothetical limit to how low you could orbit. But since planets aren't perfect inelastic spheres and they generally do have atmospheres, there's a point below which orbiting just becomes impractical. On Earth, this is largely due to the high energy cost of trying to maintain an orbit against atmospheric drag.

Below 40 kilometers altitude it's vastly easier just to use aircraft – since you can take off, do some science and then land again and spend the night in an inexpensive motel. Any higher than 40 kilometers there's not enough air density for aeronautics, but in this region there's still a whole bunch of cost-benefit issues to weigh up. There's still a sparse atmosphere at these altitudes which means that the lower your orbit is, the more fuel you'll have to burn just to maintain that orbit against atmospheric drag. So, it works out that even though you need to burn a lot of fuel to get to a higher orbit – once you're there, you can coast a lot more because there's less atmospheric drag to contend with.

Mind you, that all assumes you want to stay in orbit for a long time – like a year or more. One of our lowest orbiting satellites, which had no rockets to correct its orbit, was Sputnik 1 which managed 1,440 elliptical orbits around Earth over the course of 3 months – where those orbits had a perigee of just 215 kilometres. However, Sputnik's orbital apogee was 900 kilometres – which will well above the relatively-circular obits of Skylab (at 235 kilometres), Mir (at 360 kilometres), the ISS (at about 400 kilometres) and the Hubble space telescope (at 570 kilometres). All these spacecraft stayed in low Earth orbits for years at a time, but only as a result of altitude re-boosting, by visiting spacecraft – and with the additional help from onboard boosters in the case of the ISS.

But anyway, that's just Earth. Even if planets don't have dense atmospheres like Earth, there are still gravitational and tidal influences to think about. A very massive satellite like a moon, in orbit around a planet creates a tidal bulge on that planet – literally stretching the planet towards itself. So for example, Phobos in orbit around Mars, orbits Mars faster than the planet rotates, so the tidal bulge it creates is pulling back on it as it goes around – which slows down its orbit. As a result of this, it's estimated that Phobos' altitude will keep declining, slowly and steadily, until it reaches Mars' Roche limit and gets torn to bits about 30 million years from now.

On the other hand, the orbital velocity of the Earth's Moon is being slowly accelerated by the tidal bulge it creates on Earth, which is constantly pushing the Moon forward due to the fact that the Earth's rotates faster than the Moon orbits. This steady acceleration of the Moon's orbital velocity is raising the Moon's orbit by around four centimetres a year.

The happy medium between the two scenarios is what's known as a synchronous orbit – where the satellite's orbital period is the same as the planet's rotational period. So, for Earth, a satellite is in a synchronous orbit at around 36,000 kilometres. For Mars, which has a similar rotational period to Earth, but a lot less gravity – the altitude of a synchronous orbit around it is about 17,000 kilometres.

However, a synchronous orbit is a knife-edge balance. So, all our geostationary satellites that are in synchronous orbits around Earth have to maintain station keeping – that is, they have to burn a bit of fuel to stay in position even 36,000 kilometres altitude. And apparently station-keeping is an even more challenging prospect around Mars, where the synchronous orbit is lower and the planet's lesser mass and gravity means its geometry is even less constrained towards forming a perfect sphere. For example, Mars has Olympus Mons, a 22 kilometre high shield volcano, while the Earth has nothing higher than the nine kilometre Mt Everest. Olympus Mons represents such a huge concentration of mass that it would give any low altitude satellite a palpable hit of gravitational perturbation as it passed beneath it.

So, in a nutshell, while low-altitude orbits are possible they are generally energy-inefficient and just-plain fiddly to manage. If you're in artificial satellite business it's much better to go high, so you can go long.

Question 2:

Dear Cheap Astronomy – How exactly do we protect planets?

Whoever fills the recently-advertised position of Planetary Protection Officer at NASA, will actually have two jobs on their hands. One job is to protect other planets from us, or at least from our microbes – and the other job is to protect our planet from microbes that might be returned from other planets.

The level of risk we may face from alien microbes is a complete unknown – since we are yet to discover any alien microbes. It's not hugely likely that a completely-alien microbe could immediately interact with Earth-based life to cause death by disease or some other metabolic disruption. The bigger risk is that such microbes (or even macrobes) would find the Earth environment agreeable and begin to proliferate unchecked. Such alien microbes might have the kind of impact that fire ants, cane toads, cats, dogs and rabbits have had on the isolated continent of Australia. None of those invasive species had any intention of conquering the endemic lifeforms – they just weren't compatible with the endemic lifeforms and they could outbreed them.

Anyway, there is a current planetary protection officer (Catherine Conley) and she has some experience with the resilience of space-borne organisms, even though those organisms are from Earth. The space shuttle Columbia's STS-107 mission in 2003 carried an experiment that investigated the growth and reproductive behaviour of the nematode worm C. elegans in microgravity – and Conley was a co-investigator on that project. Columbia and its seven-astronaut crew were lost when the orbiter disintegrated upon re-entry. But, the nematodes, housed in small canisters, survived the re-entry event and were found alive on the ground. So, on the one hand this finding supports the possibility of panspermia and on the other hand indicates that even if one of our spacecraft crash-landed on another planet, it could still infect that other planet with life-forms from Earth.

What is less certain, is whether Earth life-forms, at least microbes, could survive for long periods in the harsh vacuum of space and the harsh radiation environment of space. We are not sure whether a small colony of Streptococcus mitis, found inside the camera of Surveyor 3 after it was returned to Earth by the Apollo 12 astronauts, really survived on the Moon's surface for two and a half years or whether someone accidently contaminated it after the camera was brought back to Earth. However, a number of low Earth orbit experiments with tardigrades and other microorganisms suggest it’s possible an organism might survive a 7 month journey to Mars, although a five to ten year mission to Jupiter or Saturn is another question. And whether any such Earth microorganisms could prosper and proliferate after arriving at such alien environments is also uncertain.

Anyway, how do we do protect planets? Well, the amount of trouble you will go to depends on the planetary protection risk you will face. The relative risk of different space missions are categorised from 1-5. Category 1 missions don’t need any special procedures, while category four missions need the most rigorous interventions available and Category 5 missions are sample return missions, where Earth itself becomes a planet at risk. We also think about likelihood of contact – so a distant fly-by is low risk an orbit is medium risk and a landing is high risk. And how the mission ends is also key. Once the spacecraft is out of fuel it’s also out of control, so in the case of Jupiter and Saturn we’d rather see it descending into the gas giant than risk it crashing into potentially life-bearing moons like Europa or Enceladus.

So, we tend to build spacecraft in clean rooms and then if it’s going to a high-risk destination, we’ll actively decontaminate it with various biological solvents and then expose it to dry heat and double-check all that with biological assays and after that we’ll do our best to keep it all sealed up until launch. From there, we tend to leave it to the harsh vacuum and the harsh radiation of space to hopefully achieve the final clean-up. But since life will find a way, we know we’re only doing the best that we can.