**Question 1:**

*Dear Cheap Astronomy – What is the Parker probe and other spacecraft learning about the Sun?*

The Sun is 99.9% of the entire mass of the solar system, weighing in at 1.9 times 10 to the 30th kilograms and if you think you can comprehend how much that is, you're kidding yourself. Let's just say it's freakingly hugely massive, though on a universal scale, it is a fairly unremarkable G-type star positioned towards the lower end of the OBAFGKM range of stellar classes. Still, if you are an evolved cognitively-capable being listening to this podcast, it's likely your species arose from a similar stellar system. OBAF stars probably explode too quickly to nurture life and while those dim KM dwarfs may have lifetimes much longer than out star they can only warm planets that are within a distance equivalent to the orbit of Mercury, meaning those planets will be mostly tidally locked and in close proximity of their star's stellar flare outbursts. So, their capacity to support and sustain robust ecosystems also looks to be fairly low, based on our understanding of how life evolved on the one single planet that we know life evolved on.

In 2021, our latest solar mission, the Parker Solar Probe will pass within about 11 million kilometres of the Sun's surface at each perihelion of its 8th and 9th solar orbits. Eleven million kilometres is actually pretty close when you consider Mercury's orbit is 50 million from the Sun's surface. The Parker probe is scheduled to do at least 26 solar orbits and during its 22nd to 26th orbits it will come within 7 million kilometres of the Sun's surface. It's currently unclear what the plan is after the Parker's 26th orbit, but presumably it will just be more of the same if it remains fully operational after such close solar encounters and if it still has enough fuel.

One of the key objectives of the Parker Solar probe is to answer the long-standing puzzle of why the solar corona, the Sun's outer atmosphere of hot, tenuous plasma that becomes visible during a solar eclipse, is actually hotter than the surface of the Sun. That may sound like a trivial academic pursuit, but if we can understand why that happens then we will understand a bit more about how the Sun actually works. And, if that sounds like a trivial academic pursuit consider that we have billions of dollars of hardware in Earth orbit, as well as human beings on board the International Space Station. A big solar flare directed right at Earth could fry the electronics of billions of dollars of hardware and put our astronauts' lives at risk. From our current understanding of how the Sun works, such a big solar flare is an inevitable, but also a completely-unpredictable, event. So, by better how the Sun works, we are aiming to protect billion dollar investments, as well as people. While flying to Mars may sound way sexier, it is a very high risk endeavour with uncertain returns, beyond being able to say that we did it and bringing back a few rocks. It's way easier to justify the modest funding needed for solar research, which is largely achieved by robotic spacecraft.

Anyhow, here's a few things we've learned so far. At Earth, the solar wind streams past us in a seemingly steady radial flow, but from the Parker probe's vantage point, backed up by other data from other solar observing missions, we now know the environment of the solar corona is very dynamic. The Sun's rotation and its chaotic magnetic field lines work to throw out charged plasma particles against the Sun's gravity. These initially form the corona and then, as then, as the particles spread out further, the more diffuse solar wind. Initially, the particle outflow spirals out in the direction of the Sun's rotation, moving as much sideways than outwards and within that region there is considerable magnetic turbulence, including what are called ‘switchbacks’ where an outwardly-directed magnetic field line momentarily flicks back on themselves before continuing outward. Those magnetic switchbacks flick out bursts of hot plasma which add to the general energetic chaos of the solar corona. The court is still out, but this does give some weight to the growing hypothesis that all the turbulence, chaos and hence kinetic energy in the corona could explain why it’s hotter than the Sun’s surface. No-one’s calling this decided yet, but it seems to be where we eventually might land on this long-unresolved issue.

Apart from all that, Parker discovered evidence of a cosmic dust-free zone extending nearly 6 million kilometres out from the Sun, because any cosmic dust particles that get that any closer get vaporized. This finding is not such a surprise, more a finding that confirms what we might have assumed was the case, but in science one should never assume – we always need the data to confirm.

**Question 2:**

*Dear Cheap Astronomy – Will there really be spacecraft that can travel in deep space but can also land on planets?*

Probably the best examples of fictional deep space craft that can also land on planets are found in the Star Wars franchise, where most spacecraft seem to be both able to land and zip between stellar systems via hyperspace, whatever the heck hyperspace is.

The obvious advantage of ships like the Millenium Falcon is that you don’t have to swap vehicles to go from interstellar flight to a surface landing, which saves a lot of time and packing and unpacking, since you can just swoop down to grab fresh supplies from the surface and then immediately continue on your journey.

However, there are various complications involved in swooping down to a planet’s surface that you don’t face when flying through deep space. A planet is also a gravity well, so your deep space propulsion system, which will mostly involve a main drive to propel you forward and a few lateral thrusters for trajectory corrections has to deal with a whole bunch of new challenges, where moving down a gravity well mostly involves slowing yourself down until you eventually soft-land on the surface. Achieving that may be as simple as going down backwards and retro-firing your main drive, although it’s rare that you see any fictional spacecraft doing that.

The other thing you encounter with planets is their atmospheres, which you can use to your advantage both to slow down and to glide in laterally to a soft landing, but all that puts a lot of stress on your vehicle, plus you’ll need a heat shield, flaps and landing legs – which represents a lot of extra mass and infrastructure that will be completely useless for deep space travel. It’s kind of like a car with a caravan – the caravan means you can do certain things that others car drivers can’t, but with a caravan there’s no way that you’re going to keep up with those other car drivers on the open highway, nor will your fuel economy be as good. So, the idea that you can have a deep-space vehicle that also lands on planets and that can also do the Kessel run in record time is pretty dubious. Ships that break Kessel run records will be ships that are purpose-built to break Kessel run records, not some hybrid all-rounders.

Furthermore, whatever technological marvels your ship may carry, there's still the fundamental issue of money, or whatever the 24th century equivalent of that may be. To pick up supplies from a planet's surface you first have to burn fuel to land and then burn more fuel to get both your ship and your new supplies back out of the gravity well again. So in a thriving space economy, it's very likely that all bulk trade will be done in orbit. Planets' governments might welcome visitors to the surface, but they probably wouldn't welcome them coming in on foreign spacecraft with poorly-maintained engines that might pollute the atmosphere or even crash. So, for anyone wanting to go down to the surface, there'd be various taxis and rental options. If you were determined to land your own vehicle, you'll probably need a permit and some kind of long-term registration to confirm your vehicle was adequately maintained and you'd probably need lots of insurance on top of all that anyway.

But OK, in the future there really might be scout ships working out past the edges of civilisation, exploring strange new worlds that don't have orbital depots or waystations. These ships will be big and clunky – that is, not fast, but able to multi-task both long haul deep space travel and planet landings. But, it's still unlikely even those ships will actually land. Those ships will either carry Star Trek type shuttle craft or there'll be a bit of the ship that can detach to become a lander – returning back to rendezvous with the mothership in orbit after its job is done. Or of course we could just send the landers on ahead remotely and rendezvous with them in a sleeker faster personnel carrier. At the end of the day, it doesn't matter how long it takes to send the machinery, but it does matter how long it takes to send the people.

Of course, Space-X is currently talking up the idea of flying their starship through deep space to land on Mars. To whatever extent that's possible, they still then have to launch off Mars using locally-resourced fuel, which is easier said than done. So, maybe it will happen, but maybe it won't – for all the reasons we've outlined here.