Question 1:

Dear Cheap Astronomy – Woo hoo another Mars rover.

OK, not so much a question as a yay team exclamation, but let's run with it. The Perseverance rover and its little buddy Ingenuity the helicopter launched on 30 July 2020 and will arrive and land on Mars on 18 February 2021, all going well. That's about 6 and half months – so over that time Earth will be on the other side of the Sun from where it is now – whereas Mars which moves slower and has a bigger circumference orbit will be about a quarter of the way further around its orbit.

Having left Earth Percy and Inga are packed tight in their cruise-phase spacecraft which will need to accelerate to climb further out of the Sun's gravity well – which is called Trajectory Correction Maneuver 1, or TCM 1 – then it will have to line itself up with Mars' orbit TCM2 and 3 and then as it catches up with Mars it will have slow itself down, TCM 4, 5 and 6, which all happen within 9 days of its arrival in February 2021.

Percy will land in Jezero Crater, which is nearly 50 km in diameter and thought to have been once filled with water and Percy will land near one edge of Jezero at what's looks to be a river delta where water flowed from a tributary into the crater depositing lots of sediments in a delta shape. The main purpose of Percy's mission is to find evidence of past life, where Curiosity's main purpose was to investigate the potential habitability of Mars.

Percy is around 150kg heavier than Curiosity, with Inga only representing only 2 kilograms of that extra mass. The rest is mostly new hardware. So for example Percy has more robust wheels, than Curiosity's, which have suffered a lot of wear and tear since it arrived at Mars in August 2012. Percy also carries the Moxie O_2 converter which will use electrical power from Percy's radioisotope thermoelectric generator to produce oxygen through conversion of Mars largely C_{O2} atmosphere. This is just a proof-of-concept trial, the oxygen won't be used for anything it will just hopefully demonstrate a reliable way to make oxygen from Mars' atmosphere – which would be quite something. Moxie which just be run intermittently – for one hour at a time. In that hour it should be able to make 10 grams of oxygen, which would be about 7 litres of oxygen at Earth standard temperature and pressure, theoretically enough to keep one adult human alive for 15-20 minutes or otherwise make a tiny contribution to a rocket's fuel tank.

Percy also has a sample caching system. So it can drill out rock cores and pick up regolith and then store them in 43 sample tubes which will be hermetically-sealed and then dropped at several caching sites that will be meticulously documented so later missions can come and pick them up. Percy is also carrying five witness tubes, essentially control samples which were packed on Earth and stored aboard well before Percy launched. So, these control samples will help future analysts know whether anything from Earth could have contaminated the Mars samples.

Inga will be released fairly early in the mission to undergo a 30 day trial involving at least five flights of no more than three minutes at a time and no more than one per day – Inga is solar powered so she has her limits. Percy will drop her off and then observe the trial from a distance. If the trial is successful, more work with Inga might be considered, but since that requires Percy to stay nearby in order to relay instructions and then get the data back to Earth, it's most likely that Inga will just be left behind once the trial is done.

Percy also has a ground penetrating radar. RIMFAX, that might be able to visualize underground structures down to 10 metres or more. It also has SuperCam, an upgrade of Curiosity's ChemCam which analysed rock chemistry by vapourising the rock surface with a laser and then spectroscopically analyzing that vapour. Supercam works in a similar way but with two lasers, a red and a green one.

If you just want a quick line for your next dinner party – the Perseverance rover has better wheels, a helicopter, a thing that makes oxygen, a radar, various other scientific gizmos and more cameras. And just like Curiosity, Percy can also fire fricking laser beams - two of them now.

Question 2:

Dear Cheap Astronomy – Who else in going to Mars in the 2020 launch window?

To get from Earth to Mars with our current technology we have to use time-limited launch windows to minimize fuel requirements as well as minimizing the travel duration. So our current strategy is for a spacecraft to leave Earth in the same direction that the Earth is moving around the Sun – meaning that any fuel burn just adds to the solar orbital velocity the spacecraft already has by virtue of launching from Earth. And since the spacecraft flying within the Sun's gravity well all it has to do is accelerate so as rise up the well to Mars orbit.

The fuel-minimising trick is to raise the spacecraft up to Mars' orbit just as Mars is passing by. If it's not then the spacecraft would either start falling back towards the Sun or need to burn more fuel to intercept Mars at a different point in its orbit. The current approach is to accelerate the spacecraft into a Hohmann transfer orbit – a solar orbit that has its apoapsis at Earth's orbit and its periapsis at Mars' orbit. This requires less energy than you'd need to adopt a proper Mars orbit – instead you follow the Hohmann orbit and if Mars is there when you briefly intercept Mars orbit, then Mars gravity will grab you and keep you in its orbit. So, time-limited launch windows are the way to go where there was a launch window to Mars around July 2020 and since Mars windows come around every 26 months, the next one will be in September 2022.

Initially four spacecraft were scheduled to launch to Mars in the July 2020 launch window. However, the European Space Agency's ExoMars rover, now called Rosalind Franklin, has been postponed until the subsequent 2022 launch window due to doubts about the reliability of its descent parachute system. The ESA are understandably nervous after their ExoMars Schiaparelli lander crashed in 2016, subsequent review of the telemetry indicating that the automated landing system had gone through all the phases of parachute deploy, braking thruster firing and activation of ground systems while it was still more than 3 kilometers above the surface – hence the crash.

The remaining three spacecraft which all successfully launched were the United Arab Emirates Hope orbiter, which launched on July 19th 2020; the Chinese Tianwen 1, launched on July 23rd 2020 and which incorporates an orbiter and a lander and a rover; and finally the Mars 2020 rover, now called Perseverance, which launched on July 30th 2020 and which we covered in detail last week.

To give some idea of the current internationalization of space, the Emirates Hope orbiter was launched on a Mitsubishi H-IIA rocket from Japan. It's hoped that the Hope orbiter will go into an equatorial orbit around Mars and stay there for at least one Martian year – which is 23 months, or almost two Earth years, to study seasonal changes in the Martian atmosphere – which means it's studying Martian climate and weather.

Tianwen 1 will enter Mars orbit in February 2021, but it will probably then stay in orbit for two to three months, while assessing the atmospheric conditions below before its lander attempts a landing. The lander will undertake atmospheric entry in an enclosed capsule then deploy a parachute and final retro-rocket burns to get it to the surface. If all goes well the 240 kilograms solar powered rover will then roll off the lander to conduct a minimum 90 day exploration of the Martian surface looking for evidence of present or past life. There are rumours the rover might also be able to collect rock and regolith into cache sample containers for later return to Earth by a future Chinese mission. The rover will also have ground penetrating radar, a magnetic field detector and a number of cameras.

Mars missions remain high risk, so who knows if they'll get there - they are all due to arrive in February 2021. NASA's rover probably has the best chance because it's using already-proven hardware. Whatever though, they're all human race spacecraft in the end. Ad astra.