Question 1:

Dear Cheap Astronomy – How do you think Hyabusa 2 will get on?

The list of deep space sample-return missions is surprisingly short, where deep-space excludes any sample-returns from Earth orbit or from the Moon. As far as deep-space sample return missions go, you've got is Genesis (in 2004) which collected solar wind particles from space, but crashed on its return to Earth, contaminating much of the returned samples – meaning that it's only listed as a partial success. Then you've got Stardust (in 2006) which successfully collected and returned particles from the tail of comet 81P/Wild. Then there's Hyabusa 1 which successfully reached its target, asteroid 23145 Itokawa, but its sample return system didn't deploy properly. It did return a few grains of material to Earth, but is also listed as only a partial success.

And that's about it. Phobos-Grunt had high hopes of collecting a sample from Mars' moon Phobos, but failed before it even left Earth orbit. Two further deep space sample return missions are currently underway: NASA's Osiris-Rex will reach its target, asteroid Bennu, in August 2018 and JAXA, the Japanese Space Agency's, Hyabusa 2 has just now reached its target, 162173 Ryugu as of late June 2018.

Here at Cheap Astronomy, we think that Hyabusa 2 will get on just fine. Now, that it's arrived, Hyabusa 2 will remain at the Dragon Palace, which is what Ryugu means in Japanese, for 18 months, surveying it and also deploying four small rovers – well, tumblers really. There's not enough gravity to keep a wheeled vehicle on the surface, instead the rovers will just flip-flop themselves around using internal mechanisms similar to spacecraft reaction wheels. Three such tumblers are contained in a lander called Minerva 2 – a descendant of Minerva 1, which failed to deploy as a rover in the Hyabusa 1 mission.

And this says something about scientists and engineers. Diplomats and bureaucrats might have changed all the names to ensure no-one connected the current mission with a previous failure – but for scientists and engineers, failure is a rich source of data that helps you get it right next time. In other words, rather than revising history – they learn from it. Failure might not be an option, but it certainly helps you to achieve success.

So, you might not be surprised to learn that Hyabusa 2's sample collection strategy builds on the mostly-failed strategy used in the Hyabusa 1 mission, where the spacecraft will softly touch down and fire a projectile into the surface to throw up debris that will then be collected as a sample. But Hyabusa 2 will go further than that by also placing a bomb on the asteroid. The SCI, the small carry-on impactor, is a 2 kilogram chunk of copper contained within a nearly 5 kilograms of the plastic explosive HMX.

The bomb, sorry the SCI, will be deployed to hover just above the surface of the asteroid while Hyabusa retreats to a safe distance. Running off a timer, the bomb will explode and the chunk of copper will impact on the surface and hopefully expose underlying material that's never been exposed to 'space weathering' – that is the effect of solar wind, solar heating, extra-solar cosmic rays and various particle impacts that the surface of a body in the Solar System is routinely exposed to. Hyabusa 2 will wait for about 2 weeks after the explosion, to ensure any floating debris has cleared and then descend down to the freshly-exposed surface to collect a sample.

Hyabusa 2's investigation of the Dragon Palace will continue from June 2018 until December 2019 and then it will return its collected samples to Earth in December 2020. It hard to believe that every component of the mission will perform flawlessly or in the tightly choreographed routine that is currently planned. But if most of it or even some of it works out, particularly the bit with the bomb, then that will be just awesome.

Question 2:

Dear Cheap Astronomy – What do we know about New Horizons' next target?

On the first of January 2019 New Horizons will do a fly-by of MU69 – which now carries the unofficial title of Ultima Thule, following a public ballot. The name Ultima Thule hasn't yet been endorsed by the International Astronomical Union and it will be the New Horizon team's privilege to seek the IAU's endorsement of a final name after the fly-by happens. They may suggest Ultima Thule, but if MU69 turns out to be binary or a conglomerate or some other totally unexpected thing, they may suggest a completely different name that better fits. For the record, the most popular name in the public ballot was MoreNear (spelt Mjolnir), which is Thor's hammer. Ultima Thule actually came 7th in the ballot and Kuiper McKuiper belt face didn't even make the short list.

Anyhow, its complete current name, 2014 MU69 comes from its discovery by the Hubble Space Telescope in 2014. The object was then estimated to have a diameter of between 30 and 45 kilometres. However, in 2017, occultation observations were made, meaning we watched how MU69 obscured background stars as it passed in front of them. These observations suggested MU69 is a lot longer than it is wide and it's probably double-lobed. Current thinking is that MU 69 is a contact binary, meaning that long ago two smaller objects that met and loosely joined in a gravitational embrace – one that was strong enough to keep them together, but not strong enough to completely merge them – hence giving MU69 an elongated double-lobed shape.

And the long axis of MU69 appears to be pointed our way. This is good news because New Horizons is flying outwards from Earth in a roughly straight-line trajectory at around 60,000 kilometres an hour. At that speed, it won't be able to do much more than swivel its cameras around to take a few snaps of MU 69 as it shoots past. So, it's good that it will be flying along MU69's long axis when it does pass because we'll see more surface area that way.

We also think that MU-69 is red. This is apparently characteristic of what are known as cold classical Kuiper belt objects, KBOs. These things are called cold classical KBOs because they follow circular obits around the Sun that are well outside the orbit of Neptune. The other main class of KBOs, plutinos, follow more eccentric orbits that, like Pluto, occasionally bring them within the orbit of Neptune and hence bring them a tiny bit closer to the Sun. So, it's thought that cold classical KBOs are less affected by temperature swings that the warmer plutinos experience - and for that reason cold classical KBOs may be the most unchanged objects in the Solar System.

And current thinking is that any such unchanged objects in the icy outer regions of the Solar System should be red. That red indicates the presence of tholins, which form from the ultraviolet irradiation of methane and ethane ices. So, tholins should be present on the surfaces of both cold classical KBOs and plutinos. But remember New Horizons close-up snaps of Pluto showed only patches of red upon a multi-coloured and relatively-fresh surface. That unexpectedly-fresh surface might be because of glacial melting or some kind of ice-based plate tectonics. So, since MU 69 is not a plutino but a cold classical KBO, we think its surface will be uniformly-red because it doesn't experience major temperature swings, so it should have a uniformly red surface. Well, apart from some cratering. Anything sitting out there for billions of years is going to get hit by odd, random impacts every now and again – and in the absence of any Pluto-like resurfacing events, those craters will remain as a permanent record of past impacts.

But of course, here at Cheap Astronomy, we'd almost put money on MU-69 turning out not to be heavily-cratered, uniformly-red or a double-lobed contact binary because surprise is a fundamental part of discovery.