Question 1:

Dear Cheap Astronomy – If Venus is our ‘sister planet’, why is its atmosphere under such high pressure?

It’s true that Venus is sometimes referred to as Earth‘s sister planet, but this is largely due to its radius being 95% of Earth’s. Its mass is only 82% of Earth’s and its surface area is only 90%. Earth is bigger and also denser. Indeed Earth is actually the densest planet in the solar system. This may be because of the hypothetical collision between a proto-Earth and a hypothetical object called Thea. It is hypothesised that during that collision most of Thea’s inner core joined with the proto-Earth’s inner core, while much of proto-Earth’s thin outer crust, and much of Thea’s thin outer crust, exploded outwards – later coalescing in orbit to form the Moon.

So Earth and Venus are certainly not identical twins – and their atmospheres are worlds apart (small astronomy joke there). The atmospheric pressure at Venus’s surface is 90 times that of Earth. The reason for the substantial difference is all about the different composition of the two planet’s atmospheres.

Venus’s atmosphere is 97% carbon dioxide, while Earth’s atmosphere has only zero point zero 4% carbon dioxide. The higher atmospheric pressure of Venus is a consequence of CO2 being much heavier than the major components of Earth’s atmosphere, nitrogen and oxygen. A heavier gas means a higher surface pressure.

The reason why Venus has so much more CO2 than Earth is because any CO2 released by Venus’s geothermal activity just adds more gas to the atmosphere – there’s nowhere else for the CO2 to go.

So rather than asking why Venus’s atmosphere is so weird, the better question to ask is why Earth’s atmosphere is so weird. The answer to that is that Earth has oceans. The oceans can dissolve a lot of CO2 and organisms in the ocean can integrate that carbon from CO2 into shells and other structures. Once dead, the remains of those organisms sink to the bottom and ultimately get subducted back into the Earth’s crust by plate tectonics. So carbon, sent into the atmosphere by volcanos, is ultimately returned underground.

Having no oceans, Venus can’t have life as we know it and nor can it have plate tectonics, which needs water for lubrication. So as CO2 comes out of Venus’s crust it just builds up in the atmosphere.

It is thought that Venus may have once been Earth’s sister planet – at least for a fleeting moment. It may have started with a similar water content, but being closer to the Sun, that water couldn’t stay in liquid form. And there’s the rub.

Unfortunately, one of the worst greenhouse gases of all is water vapour. Being further away from the Sun, Earth’s water vapour tends to cool and fall back to the surface as rain or snow before it builds up in any significant quantity.

On the early Venus, any evaporated water, stayed evaporated causing a greenhouse effect that quickly evaporated any remaining water on the planet. Any water vapour that was in Venus’s early atmosphere was steadily broken down into hydrogen, which was lost to space, and to oxygen which would have quickly oxidised with something – as free oxygen is want to do. The only reason we have free oxygen in Earth's atmosphere is because algae and plants keep replenishing it.

So, that was that for Venus' water and as geothermal activity continued on this dry, barren world, its atmosphere became dominated by CO2, which retains heat as a greenhouse gas and also generates a crushing atmospheric pressure at the planet's surface.

I hope that answers your question.

Question 2:

Dear Cheap Astronomy – Is it Laddie or Lady… and what is this mission all about?

LADEE, pronounced Laddie, is the Lunar Atmosphere and Dust Environment Explorer, which was launched on the 7th of September 2013 from the Mid-Atlantic Regional Spaceport on Wallops Island in Virginia, USA. The LADEE mission will study the composition and structure of the tenuous lunar atmosphere, which includes any dust that may be lofted up from the surface. LADEE will also test a laser-mediated communications system, which could be the start of a revolutionary new way to manage Earth-to-spacecraft data transfer.

You might be surprised to hear that the Moon has an atmosphere – and, well it doesn't really. It has what we call a surface boundary exosphere.

In a thick atmosphere like Earth's, gas molecules are constantly colliding with each other and hence moving in random and frequently-changing directions. In an exosphere, there are no such collisions and instead the scant particles in it follow largely uninterrupted straight-line paths around a celestial body that can generate enough gravity to hold onto them.

Earth's exosphere is over 500 kilometres from the surface. But for celestial bodies with no atmosphere, but enough gravity, an exosphere becomes bound to it just above the surface. Hence the term – surface boundary exosphere. Other celestial bodies with surface boundary exospheres include Mercury and most of the larger asteroids and Kuiper Belt objects.

A key goal of the LADEE mission is to learn about the dynamics of a surface boundary exosphere. Indeed, there is a real imperative to undertake this research as soon as possible. Increasing interest in exploring the Moon, will lead to an increasing frequency of lunar missions that will change the natural composition of the lunar exosphere, both through stirring up surface dust and through the addition of rocket exhaust components.

The Moon's surface boundary exosphere was first sampled during the Apollo 17 mission, which identified helium and argon, as well as traces of neon, ammonia, methane, and carbon dioxide. Subsequent spectroscopic analyses from Earth telescopes have since found sodium and potassium atoms as well.

These components of the lunar exosphere may have originated from:

1) Atoms knocked off lunar surface material by the solar wind;
2) Dispersed debris from comet and meteor impacts; and
3) A tiny amount of out-gassing from the Moon's interior.

Another goal of the LADEE mission is to determine the cause of the curious rays which were reported by Apollo astronauts to precede a sunrise and follow a sunset as they orbited the Moon. The same phenomena were also photographed by Surveyor probes from the lunar surface. These rays may result from light diffraction by dust particles or from the glow of energised sodium atoms.

As well as pursuing these science objectives, LADEE will undertake the Lunar Laser Communication Demonstration to test the feasibility of communicating data using infra-red laser light instead of radio. Since infra-red has a shorter wavelength than radio, it can carry more information within the same transmission time.

High data rate transmission is becoming increasingly important in space exploration, as our spacecraft become increasingly able to undertake higher-resolution observations. Decreasing the time needed to stop and transmit data back to Earth will increase the amount of time that our robot spacecraft can get on with exploring the universe – because that’s what it’s all about.