Question 1:

Dear Cheap Astronomy – how long until we won't be able to hear the Voyager spacecraft anymore?

Just to clarify the question, the problem won't be about our hearing them, but about the spacecraft ceasing to transmit once they run out of electrical power. The two close-to-identical Voyager spacecraft launched in 1977, Voyager 2 on the 20th of August and Voyager 1 two weeks later on the 5th of September. The trajectories and orbital mechanics involved in getting to their first mission objective, a fly-by of Jupiter, meant that Voyager 1 would arrive there first, despite it launching second. So, NASA called it Voyager 1 to avoid confusing the newsreaders of the day.

Both spacecraft have radioisotope thermoelectric generators (RTGs), which work by using the heat from a decaying lump of plutonium isotope 238 to generate electricity. Since we know the half-life of those lumps fairly exactly, we already know that after 2020 there won't be enough power to continue running all the currently-operational systems and by around 2025 whatever work-arounds we have managed will fail as both spacecraft lose the capacity to collect and transmit data. After that, they will carry on silently with their golden records attached, time capsules from 1997 Earth for any aliens that find them. Although, given the time periods involved, it's possible that human-crewed spacecraft might overtake them before that ever happens.

Voyager 1 will make a first close pass of another star, called Gliese 445 in about 40,000 years. This is surprising since Gliese 445 is over 17 light years from Earth and Voyager 1 needs 17,000 years to cross just one light year. The reason for this is that Gliese 445 is heading for a fly-by of the Sun and 40,000 years from now it will only be about 4 light years away, instead of the current 17.

Voyager 2's journey outwards will be less eventful. It will eventually pass within about 4 light years of Sirius, but that will not happen for another 300,000 years.

This might give you some idea of the different perspectives required when thinking about interstellar travel. First it takes a ridiculously-long time to get anywhere and second, over those long time periods, things tend to move around a lot.

But anyway before they sign-off, the Voyager's still have an important job to do – and they should get it done well before 2025. Their current mission is to fly into interstellar space and to send back data to Earth about what interstellar space is like. We won't get pictures, since their cameras were disabled a long time ago – all we would see is black with a few background stars anyway. What we will get is magnetic data, spectroscopic data and also some plasma data.

Everyone has their money on Voyager 1, which is over 18 billion kilometres way – or about 17 light hours. Voyager 2 is only 15 billion kilometres away (or 14 light hours) – although it is heading south from the solar system where the heliosphere is shrunken inwards, so Voyager 2 may cross over quite soon as well.

The magnetic data the probes are sending back is the key to knowing when the spacecraft are really in interstellar space. The data from Voyager 1 indicates that it is now in a region where charged particles are moving laterally rather than outwardly – what NASA is calling 'the magnetic highway'. This is presumably the very edge of the bow wave that the solar system is pushing out ahead of itself as it orbits the galaxy. Crossing this region may take weeks, months or even a year or more, but there's a growing excitement as people scan the data and ask the question – are we there yet?

Question 2:

Dear Cheap Astronomy – What's will the new Mars Rover, planned for launch in 2020 look like?

NASA's December 2012 announcement that a new Mars rover would be launched in 2020 has left a lot of room for speculation about what the mission's objectives will be. The rover will have the same chassis design as the Curiosity rover which is now on Mars and it will land on the surface using the same successful entry, descent and landing system Curiosity used. However, it is likely that the 2020 rover itself will carry a very different scientific payload and will hence be a very different rover and have a very different mission.

The 2020 mission's preliminary budget has been set at $1.5 billion, substantially less than the $2.5 billion of the Curiosity mission. Savings will be made through re-using much of the Curiosity mission's engineering designs, including the complex combination of aeroshell, parachute, descent rockets and sky-crane which successfully landed Curiosity in August 2012.

Of course, re-using these engineering designs means that the 2020 rover will need to be of a similar size and a similar mass to Curiosity. The 2020 rover is also expected to be powered by a spare MMRTG, that is a multi-mission radioisotope thermoelectric generator, which is a close-copy of the unit which currently provides electric power to Curiosity.

This is about all the information we have at the moment and the science payloads that may be added to the new 2020 rover's chassis remain to be decided on. The next steps will be taken by the Science Definition Team, whose brief is to establish "science goals and measurement objectives", which will be contained in a report due to be released in July 2013. This report will then inform what NASA calls an Announcement of Opportunity, essentially a call for submissions of costed proposals to build key components of the new rover. That announcement will happen later in 2013.

Nonetheless, there has been considerable speculation about what the new rover's science capabilities may be. For example, a 3D camera proposed by James Cameron was originally flagged to be part of Curiosity mission and might be revived for the 2020 mission. Just in case you didn't know, James Cameron was the guy who directed The Abyss and Aliens 2 – his career kind of sank after that.

Another suggestion is to equip the 2020 rover with a caching facility, which had originally been proposed for the cancelled 2018 MAX-C (Mars Astrobiology Explorer-Cacher) mission. Caching means collecting and storing Mars rocks and regolith in a suitable container, which might then be collected by a subsequent Mars sample-return mission.

In fact, current thinking is that a successful Mars sample return will require three separate missions to be launched. First a rover, like the 2020 rover, will collect and cache suitable samples in a sealed container. Second, a new spacecraft will be put in Mars orbit, which has the capacity to send a sample container back to Earth. Third, a Mars Ascent Vehicle (a MAV) is landed on Mars, carrying a scaled-down rover that has the sole task of retrieving the cached sample container and returning it to the MAV. The MAV then launches the sample container up to the orbiting Earth-return spacecraft, which then launches it on a return-trajectory to Earth.

It might sound very complicated but remember, this is rocket science.