Hi, this is Janet for Cheap Astronomy, www.cheapastro.com. This is SISS, Science on the ISS – and today's episode is *Gravity matters.*

A somewhat frustratingly-high level of research on the ISS is directed towards investigating the effect of microgravity on people. It is somewhat frustrating because no-one in the space exploration business seriously believes that human beings are going to be exploring the cosmos in microgravity. Our long range spacecraft and colony ships will have various artificial gravity solutions, mostly involving centrifugal force or just by the acceleration of the whole ship – where we spend half the journey speeding up then turn the ship 180 degrees and spend the other half of the journey slowing down, meaning the floor remains the floor throughout the journey, due to acceleration.

Of course, for the ISS the term microgravity is somewhat of a misnomer since the ISS is only 400 kilometres above the surface of the Earth and hence is exposed to around 80 per cent of the gravity that we live in down on the surface. The reason that everyone floats around in the ISS is because both they and the ISS are in free fall.

But, once we eventually do get out there exploring deep space, the term free fall will become a bit of a misnomer since we will be floating out in empty space without actually falling towards anything. This is why we use the term microgravity in connection with any kind of spaceflight – even boring, low-Earth orbit spaceflight.

Anyway, microgravity is bad for your health and introduces a whole range of engineering problems. Under gravity, fluids will fall and hot air will rise – which vastly simplifies basic issues like plumbing, air-conditioning and lubrication. With gravity you can also sift and sieve granular materials, which can come in handy for anything from food preparation to mining. And of course, with gravity – when you put something down, it stays down.

But putting all that to one side, a huge proportion of ISS research is focused on the effects of microgravity on people – that is, *astronauts*. The most-pressing needs for ISS research are to fulfil our plans of going to Mars, as well as undertaking other long haul space journeys. Unfortunately, it's not on anyone's radar to start building giant long haul ships that can generate artificial gravity, even though everyone knows that's eventually what we'll end up doing.

So, everyone who's demanding that their government, or someone else's government, start funding a mission to Mars needs to start caring about the microgravity problem. A mission to Mars means astronauts will be in microgravity for about three years – well, apart from some brief periods of acceleration and deceleration– and perhaps a brief stroll on the surface of Mars halfway through. We have no idea what three years of microgravity will do to someone, in fact we're not even sure what two years of microgravity will do to someone. But it is pretty clear from what we've seen so far that it's probably *not* going to do anything good.

For example, microgravity can mess up your eyesight. A NASA survey of 300 male and female astronauts, found that around 23 percent of short-flight and 49 percent of long-flight astronauts reported problems with both their near and distance vision during a mission – and for some those vision problems persisted for years after their flight. 100% of a group of astronauts whose eye anatomy and eye fluid pressure have been carefully monitored in microgravity have had changes in the shape of their eyeball, as well as changes to their intraocular fluid pressure.

For reasons that are not yet clear, the back of the eyeball, which is where your retina and your optic nerve are, tends to flatten out over time in microgravity. The most likely cause of this is fluid accumulation in the head, which happens because gravity is no longer steadily dragging that fluid down towards the toes. So… given that a Mars mission might mean 3 years in microgravity, unpredictable changes in astronauts' visual acuity is what the experts call a *non-trivial* problem.

We have no current plans to add an optometrist to a Mars crew, so if two years into the mission the first Mars crew find themselves squinting to read the control panel, going back home for a new pair of glasses is not an option. Squinting at the control panel might not be immediately life-threatening – but add an emergency situation, say with smoke in the cabin, and it really could become life threatening. And that's all assuming that the worst that will happen to you after three years in microgravity is that you'll just have to squint a bit. We don't actually know *what* will happen, because no-one has ever been in microgravity for that long.

Future generations may well scorn us for even contemplating exposing someone to the slow accumulating torture of living in microgravity for 3 years. They will certainly shake their heads at the primitive space-farers' failure to realise how much trouble might have been saved by just building spacecraft with large spinning structures that generated *macro*gravity.

But with that option still many decades away, surely we now have to do whatever we can to protect the first vanguards of humanity to travel to another planet. And the best thing we can do to protect those people, those astronauts, is research – *lots* of research, including lots of ISS research.

After many years of research already, we are starting to get on top of the fact that microgravity makes your bones dissolve. We have developed careful diet and exercise regimes that will significantly slow that dissolving and will also help reduce the muscle wastage that goes along with it.

And we are totally on top of the iron toxicity problem. In microgravity your heart doesn't have to work nearly as hard as it does on Earth, where your heart has to pump fluid volume against gravity. So, in space, your body, being a natural energy conserver, reduces your blood volume and its contents. Fewer red blood cells means less haemoglobin – and less haemoglobin means less iron usage – so you suddenly have an excess iron problem.

Iron, like other heavy metals, such as mercury and lead, is difficult to excrete – mostly because prior to the industrial age we were never exposed to high levels of it – and so there's been no time for evolutionary changes to deal with the problem.

The best way to deal with iron toxicity is not to get it in the first place. All our Mars-bound astronauts will have to do is avoid iron-fortified processed foods. These were standard fare in early missions of the 60's and 70's, but they got phased out as soon as orbital research revealed that there was a problem.

In hindsight, it's lucky that some gung ho NASA administrator didn't decide that *hey, we've gone to the Moon – so what the heck, let's go to Mars now*. That probably wouldn't have ended well – with squinting, osteoporotic astronauts dying of iron toxicity induced liver failure, just a year or two into the mission.

So, if we want to go to Mars, the first priority is keep the astronauts alive and well. NASA is currently trialling Scott Kelly staying on the ISS for a full year in space, while his identical twin brother Mark, a retired shuttle astronaut, remains on Earth. It sounds like a publicity stunt, but actually a comparative study of genetically identical twins with similar life histories is pretty much the gold standard – of treatment versus control research. It's still only measuring the impact of one year in space, but we will learn a lot from this.

To paraphrase JFK the mission is not just to get the astronauts to Mars – but to return them safely to the Earth. There's still a lot of work to do before anyone says *T minus ten*.

Thanks for listening, this is Janet for Cheap Astronomy www.cheapastro.com. Cheap Astronomy offers an educational website where we help you keep your feet on the ground. Bye.