Cheap Trek Episode 6 (a cheap attempt at mimicking the legendary *Physics of Star Trek*).

Dear Cheap Astronomy – A Borg-like species seems technically and biologically feasible. How would we humans measure up against such a threat?

The Borg were a collective of humanoids with lots of tech-gear and tubes stuck into them. Their collective intelligence was maintained by some form of electromagnetic radiation, which could be actively blocked to isolate individuals, but they also sometimes returned to a docking station, presumably for maintenance, upgrades and updates – and probably also to be turned off and turned on again, which is now widely-regarded across the Universe as the best way to fix pretty much anything.

Before we go too far with this, it's necessary to deal with the issue of the Borg Queen introduced in the movie *Star Trek: First Contact*. While a useful plot device, assigning a leadership role to a single individual kind-of undermines the whole Borg concept and leaves any Borg Collective at huge risk of destruction, since – as ably-demonstrated in First Contact, if you take out the Queen, you take out the collective. In reality, real colonies, like bee hives, work nothing like this – if you take out the Queen, the rest of the colony just keeps calm and carries on until a new Queen is born – which is achieved by just picking out an embryo at random and feeding it royal jelly. So, in a real Borg scenario, individuals just don't matter - and taking out any one individual out doesn't matter either – whatever master plan a designated leader was pursuing would have already been distributed across the network, so if a leader falls, the next follower in line just picks up the baton and keeps going.

So, how would we humans stack up against the Borg? Well, here we are, dominating the Earth to the extent of adjusting the thermostat while the poor-old bees haven't even landed on the Moon yet. So, clearly our self-centred, me-generation, capitalist, make-your-own luck species just totally rule, right? Well, maybe we do, but consider whether that might be because we pretty much are Borg already.

Firstly, consider just how indispensable human individuals really are? Of course we all like to think we are indispensable – and generally we have family members ready to back us up on that. And there's no doubt some individuals really have changed the *course* of history – even though, for the most part, history was moving in that general direction anyway. If the Wright brothers hadn't flown – someone else would have done it soon after. And it's pretty likely we'd still have telescopes today even if Hans Lippershey hadn't invented one and if Galileo hadn't been the first to point one at the night sky. And it's hard to believe that someone else wouldn't have figured out the whole speed of light limitation business if Einstein hadn't got there first.

If you're still not convinced, consider that over half of us are now wirelessly interconnected to each other and lots of us have replacements parts, implants and gadgets embedded in our bodies – and most of us are at least educationally-engineered from childhood to become specialised in different tasks and skills. And, most of us also seem pretty happy with the idea of dronehood, readily joining large groups that follow sports teams, mythical deities or just well-known individuals who might look, sing or act well – even though such individuals have few qualities that are likely to be useful in taking over the galaxy.

So, even without being injected with nanoprobes or having various tubes and implements attached, we human beings already operate a bit like a distributed neural network. If you take one individual out it does not greatly disrupt forward progress. And we all have access to constant feeds of information, most of which is about sports and what the good-looking singers and actors are up to – but there is also information about treating diseases, educating the next generation and building rocket engines - and that information is constantly being updated too. Many of us regularly return to docking stations, also known as couches – where we absorb information through visual and audio transmission and often replenish our energy supplies at the same time – and it's not unusual that we sometimes switch off and switch on again in those situations. Resistance is futile.

Dear Cheap Astronomy – Is the artificial gravity we see in Star Trek really possible?

Well yes and no. If you spin something you can readily create artificial gravity on its outer wall. But it's pretty rare that science fiction spacecraft achieve artificial gravity by spinning – *2001: A Space Odyssey* and the more recent film *The Martian* are notable exceptions. For the most part, science fiction adopts the position of having it actors behave as though they are just walking around on a studio set on Earth, excepting rare moments when turning off the artificial gravity suits development of the plot. In those instances, it's implied that artificial gravity arises from some kind of technological mechanism, although it is a mechanism that generates very local effects. After all, when someone exits an airlock from their starship, they almost immediately experience weightless and will need magnetised boots if they want to walk around on their ship's outer hull.

There's nothing in either Star Trek, or indeed in over 90 percent of other science fiction, that readily explains what makes this artificial gravity work. People walk around inside their respective starships, climb ladders and they also slide down them again – all suggesting that artificial gravity exerts an acceleratory force that draws you down to the floor even when you are well above the floor. So, there's clearly more to it than magnetised footwear. Indeed whatever artificial gravity is, it's pretty darn effective and surprisingly versatile. A starship can undergo some extreme manoeuvres, including rapid rotation through 360 degrees or more without any of the crew losing their footing, or their seating – unless of course the ship is hit by phaser blasts or collides with a solid object, at which point everyone must immediately 'hang onto something' to avoid being thrown about the cabin.

But let's stop for a moment to think about what real gravity is. It is an extraordinary feature of our Universe that if you accumulate and concentrate mass into a small volume, spacetime gets bent towards that centre of that concentrated mass. So, if you are travelling past a planet, you will suddenly find your line of trajectory being bent towards the centre of the planet –even if you land safely on the surface you will still find spacetime is still trying to direct you down to the centre of the planet – and, as a consequence of that, you can comfortably walk around on its surface.

But applying these principles to the generation of artificial gravity in a spacecraft makes little sense, since any concentration of mass will add to the mass and the inertia of the spacecraft, meaning that you will need to apply more energy to alter its trajectory through spacetime. As general relativists like to say, mass tells spacetime how to curve and spacetime tells mass how to move. Science fiction apologists appeal to gravitons as the underlying mechanism of starship artificial gravity. But

gravitons are just the mediators of the gravitational force, you still need a concentration of mass to invoke a concentration of gravitons.

So, maybe this is another adjustment that we need to make to the Starship Enterprise, before it's actually built. Over the course of this series, we've ascertained that Enterprise's essential geometry is sound – with a low surface to volume ratio that promotes radiative heat loss. However, since warp drive is pretty much science fantasy, the Enterprise's nacelles would instead be linear particle accelerators to enable fusion-driven ion drive propulsions at potentially very-fast, though still sub-liminal, speeds.

And now we need to modify the saucer section to generate artificial gravity, presuming this is where the crew will spend most of their time. The artificial gravity would be achieved by spinning the saucer horizontally and adjusting its internal architecture so that its decks are aligned radially, rather than horizontally – so that the outermost side-wall of the rotating saucer would become its ground-floor deck.

You'd need to design entry and exit ports that would still enable access the non-rotating parts of the ship, as well as special plumbing and power conduits, but the basic engineering required would be no more complex than what we use in revolving restaurants today. Of course, the position of the bridge might need more consideration, since its traditional place in the centre of the saucer means it would be in almost zero G, which doesn't seem healthy for the captain or senior officers who, after all, always need to be in good shape to fight all those aliens with lumpy bits on their foreheads.