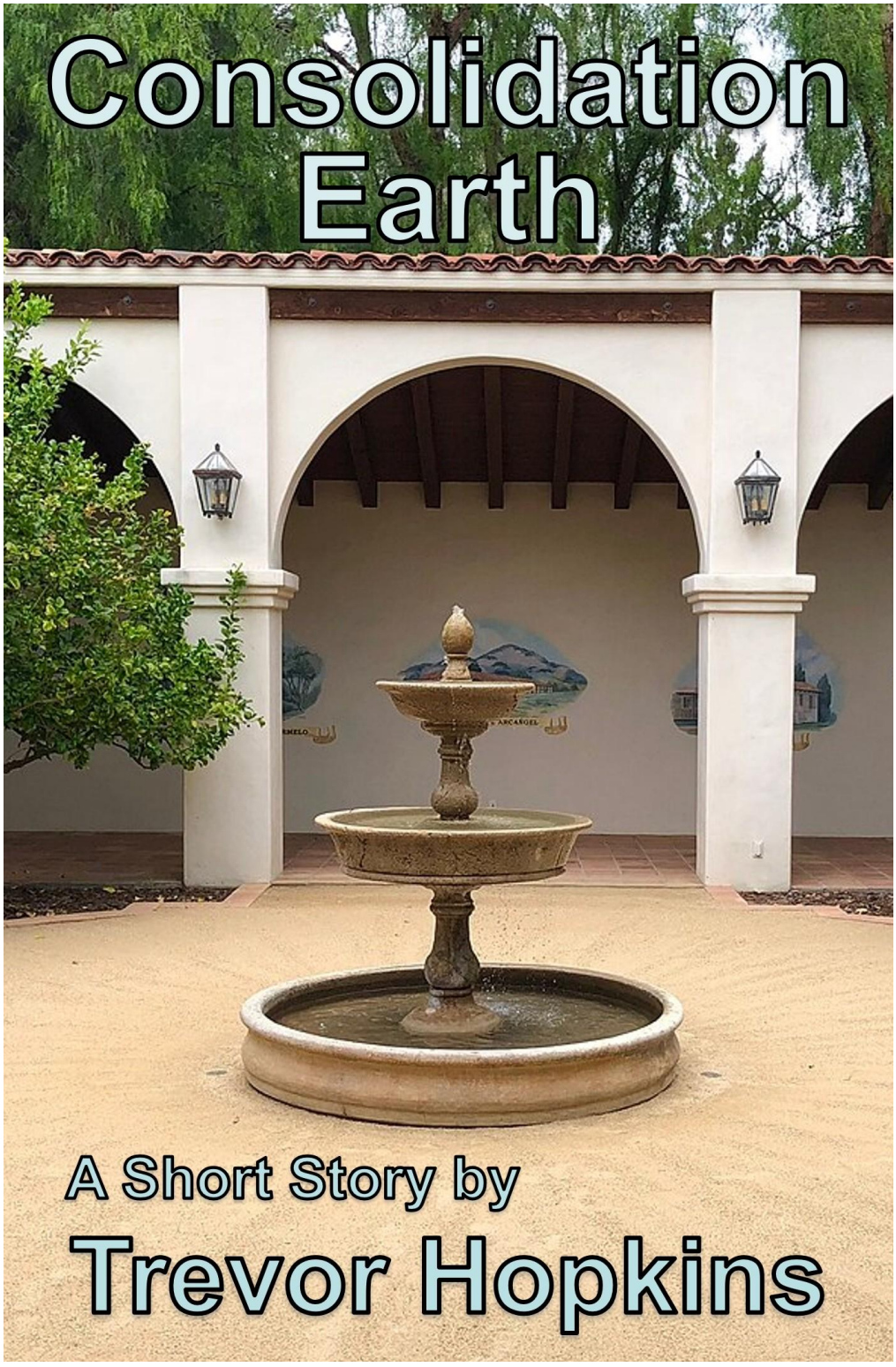

Consolidation Earth

A short story by Trevor Hopkins

The hundreds, thousands of blue lights in the night sky - and the daytime, too - gradually dimmed and reddened as the escaping spacecraft whose exhaust plasma they represented drew further away and whose speed became increasingly relativistic The lights showed the progress of hundreds of thousands - perhaps millions - of people leaving the solar system, forever, on trajectories which might take them to other stellar systems in a few hundred years' time. At least, from our perspective; relativistic effects meant that the journey time might only be a few months, from the point of view of those actually travelling.

Even now, a new light would occasionally appear in the sky as another Kuiper Belt or Oort Cloud iceball started to accelerate; there are hundreds of billions of frozen objects in the dark and far distant reaches of the solar system, hundreds or thousands of times further from the sun than the dwarf planet pair Pluto and Charon. At this extreme distance, most objects are made of ice: not just water, but ammonia and methane ice too, as well as more exotic materials which only form under conditions of extreme cold.

It was these objects that the radical Expansionists, with whom we had been at war for decades, had been secretly converting into interstellar spacecraft. Exactly how, and what, they had been doing we did not know, although our best spacecraft engineers theorised that the mass production of carbon nanotubes as a basic building material using methane ice as feedstock was essential to their engineering.

It was widely considered by even the most intransigently hawkish military commanders that there was no virtue in pursuing the fleeing Expansionists even if it was immediately practical. It was not: a whole new design of huge spacecraft would be required, with a fleet numbering in the thousands: the financial and political cost would be obviously unacceptable. The cheaper route was favoured instead: a propaganda campaign declaring that the Expansionists were no longer a threat with a strong suggestion of 'good riddance to bad rubbish'.

A Peace Dividend was declared, to general and genuinely heartfelt approval: the war in space had gone on for decades and everybody had felt the hardship, even though relatively few people had actually died. Now, there would be a substantial reduction in military expenditure, with the funds being used instead to provide better living conditions, improved infrastructure, and all the rest, although not, naturally enough, a reduction in taxes.

As a result of another intensive and highly successful media campaign, a popular movement soon formed to undo or repair or rebuild the effects of centuries of exploitation of planet Earth, the replenishment of environments damaged by rapacious misuse. 'Love our Gaia' was the rallying cry. Of course these actions took many and various forms, from planting trees and removing dams, to rewilding rainforests and refilling mines and quarries.

It also brought about a fashion for living in space, leaving Earth surface and its rivers and oceans to nature. There had been space-based fortresses and orbital military facilities for decades, all build with materials mined from asteroids; now, the same technologies were being used to fabricate increasingly large habitats in Low Earth Orbit, easily reachable from the surface by reuseable spaceplanes, and even more easily from lunar shuttles, Mars express services and the stream of transports to the Belt and beyond.

During the war, scientific research was inevitably focussed on immediate military objectives, although whether any of those innovations actually had any real impact on our battles with the Expansionists is open to debate. The Peace Dividend changed all that, not quite overnight, but surprisingly quickly; now, it was entirely possible to get funding for research in scientific disciplines with no discernible military benefit; instead, in topics which might be useful in, for example, reversing the effects of petrochemical pollution or removing heavy metal poisons from the environment.

Which is how I come in. I am Joe Momoa - Doctor Joseph Momoa, if you want to be formal - and I am a Research Fellow at the University of Hawaii at LEO, a medium-sized orbiting habitat dedicated to the university. The University of Hawai'i has long had a great many campuses on different islands, which are of necessity tens or hundreds of kilometres apart, so it was not much of a stretch, many years ago, to open another campus whose distance varied wildly but was only a few hundred kilometres away when directly overhead.

The University of Hawaii has a long history of research into both oceanographic subjects and astronomy, the Hawaiian Islands having long housed telescopes of many kinds on mountain peaks. In modern times, the university has branched out to become a leading light in space research as well as, more recently, the growing area of techniques for cleaning up the oceans.

I am researching self-assembling molecular structures, a field popularly known as nanotechnology. Of course, the world we live on is replete with self-organising molecular structures - the phenomena commonly known as 'life' - and, for many purposes, engineered microbes are an excellent vehicle for achieving clean-up of pollution: getting the bugs to eat the plastic, for example.

For other applications, though, there are real advantages to getting the devices to count and perform logic and, ultimately, make decisions, to become tiny self-replicating computers, if you like. There is a considerable body of theoretical work on how such machines should work; the focus of my work - and that of many others - is attempting to make them work in reality.

I can tell you now the behaviour of the materials we have been making do not correspond to the theory.

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Generally speaking, in scientific circles, when observations disagree with the theory, it is the theory which is wrong and needs to be revised, or thrown out entirely and replaced. The trouble in this case was that different teams achieved inconsistent results from the same experiments being performed in different

places, even when the results were consistent when performed multiple times in the same location.

This was increasingly frustrating for researchers in the field, since an important part of the scientific method is repeatability. Perhaps people were just being sloppy when reproducing the effects; maybe there was some chaotic behaviour with different emergent outcomes with only the tiniest differences in starting conditions. Nobody seemed to know.

Eventually, another scientific convention was invoked: organise an international conference on the subject and invite everybody who might have some insight into the matter. The 'International Conference on Progress on Turing-Complete Nanomachines' was held, rather quaintly, actually on the surface of the planet, in the Prague Congress Centre, tucked into the slightly newer parts of that ancient city.

With only a small amount of effort, I persuaded my university to fund my attendance at the conference, with a modest travel budget; in the event, I travelled conventionally enough by spaceplane to the Baikonur Cosmodrome in Kazakhstan and then a comfortable overnight journey by high-speed train to Prague main station.

I threw myself into the plenary sessions and paper presentations and structured debates and panel discussions which formed the formal proceedings of the event. After all, my university had given me a substantial sum of money to attend, and it would be churlish not to take full advantage of everything that was on offer. Still, I could not help but notice that there was surprisingly little actual contribution to the problem at hand: there was plenty of argument and heated discussions, but no concrete suggestions as to what was really going on.

One of the abiding features of scientific conferences is that the most fruitful discussions happen outside the formal presentations and, researchers being only human too, in the bar after the day is over. In this case, I had just settled in a bar imaginatively called (in English) Pub Two - Pub One was right next door - with two colleagues, both men, both of whom I knew slightly, although I was rapidly getting to know a lot better. One was Ted Harris, a Brit originally - not that these things really count for much anymore - and now a tenured associate professor at the Kyoto University of Advanced Science, and the other was Ken Chun, originally from some Chinese province and now attached to the University of Technology in Sydney.

The tree of us were sitting within a comfortable radius of a warming fireplace - not actually burning, of course, but a very good facsimile of flames - keeping away the chill of a northern hemisphere winter - something of a novelty for me, I admit - with large glasses of authentic Czech pilsner in front of us, shortly joined by large plates of equally authentic Czech food: heavy on the dumplings and pickles.

In this convivial old-world atmosphere, our talk turned naturally enough to the cutting-edge science of the teeny-tiny world of self-replicating nanomachines which, it seemed, we were still no closer to actually building.

"What's the most exciting thing we could do with nanomachines, if they actually did work like the theory says?" Ted said, wiping froth from his upper lip.

"Monumental engineering, even on a planetary scale," Ken replied, around a mouthful of dumpling and gravy.

I nodded. "We could engineer the Earth back to the way it was," I replied, "Or engineer Earth to be how we would like it, even if it was never like that before. There's no limitation of scale, to any project we could imagine. We just have to wait long enough and exponential growth would do the rest."

"Hah. We could engineer any planet to be the way we wanted it," Ted suggested, "Venus, or Mars. Or moons: Europa, Titan. Lots of places."

"It would be against the principles of Gaia," Ken muttered.

"Yes, it would," I agreed, "And there'd be any number of objections from environmental authorities, watchdogs, preservationists, environment risk analysts and the whole public pressure for the status quo."

"These are all be issues which would have to be resolved," Ted observed, "Whenever we make it work properly."

"I wonder if those Expansionists have made it work?" Ken mused, "It would be very much aligned with their shameful policy of spreading themselves away from Mother Earth."

Ted snorted. "Indeed. Let's not get into all that just now, huh?"

There was a long moment of silence, punctuated only by the enthusiastic sampling of beer and pickles.

After a few moments masticating, I said thoughtfully: "We need to capture the moment when the actual molecular assembly process fails. We've never actually seen it happening. Wherever it is in the overall process."

"Ye-es," Ted said, sounding uncertain, "That's true. We only know a step has failed when the following process fails to start. By then it's too late. The entire substructure has fallen apart."

"We don't have anything which could directly image the process step," Ken agreed, "The electron beams for lithography and assembly of atoms are far too energetic, and the Scanning Tunnelling Microscope doesn't really have the imaging range or depth of field."

"All true," I said, "But we could augment the apparatus with a scanning *electron* microscope."

"In the same hard-vacuum chamber?" Ted asked. I nodded.

"That might be difficult," Ken said, "There's not a lot of space in the chamber as it is."

"We could add an extension ring," I suggested, "Eight or ten centimetres should be enough. And there's probably enough spare capacity in the pump cascades to cope with the extra volume."

There was another long quiet moment, although this one did not include the consumption of food or drink.

"There's a paper in it, maybe more than one," I pressed, "We could all try this in our own labs and compare the results."

Broad smiles spread across the faces of Ted and Ken. We toasted the success of our proposal with much Czech beer.

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It took a significant amount of work to re-engineer my high-vacuum chamber and ancillary equipment to accommodate both the existing devices and a newly acquired SEM, while giving all of them targeting access to the existing mobile sample stage upon which the nanoscale device under construction - at least, attempted construction - was mounted. Of course, this also required additional funds and, as is often the case in a university environment, the acquisition of those funds took longer than the actual work itself. Grant applications and evaluation forms and peer reviews: such is the life of the professional academic.

Scanning Electron Microscopes are famous for being able to provide fabulously detailed pictures of truly tiny objects: microscopic insects, grains of pollen, bacteria and viruses are the standard examples used. What is less well known is that they have a significant trade-off between the resolution of the image they provide and the time taken to capture that picture.

Even with the most modern examples, a grainy, noisy moving feed at a few frames per second might be possible under ideal conditions: enough to be able to pan around and zoom in on a likely-looking feature. Once locked in, it might take more than a minute to capture at much higher resolution the kind of detailed picture you might expect, with any blurriness caused by the subject moving, which it would only do if you had done a bad job of sample mounting.

Finally, I was ready for a first trial. First, I progressed the build through many steps until I reached the one just before the step which always failed, confirming in the usual way that the build had gone correctly. Then I brought the SEM online, scrolling up and down while squinting at flickering fuzzy images on the computer screen until I found the half-formed nanodevice I was making and got it centred in the field of view. The device under construction looked good, and I pressed the button for a full-resolution scan, which took a little over a minute - although it felt like much longer - and produced a beautifully detailed image.

Then I turned the SEM off; I did not want the electron beams to interfere with one another. The microscope beam is relatively low power, so that it does not move around the molecules of the object being imaged, thus breaking it. On the other hand, the assembly beam actively wants to move molecules to new positions and is therefore much more powerful.

I had decided to run the next assembly operation until about half complete and then take another look with the microscope. Through the flicker and noise, I re-centred the image; the device looked pretty much exactly as I had expected, so I concluded that whatever the failure mode was had not yet occurred. I was just

about to turn off the SEM and restart the construction when I glimpsed something moving, some distance from the device.

Something was emerging from the gold foil which formed the work surface, rising up like some hunting sea creature shrugging off the seabed sand which had camouflaged it until moments ago. Whatever it was, it had an ellipsoid body with a spherical head at one end and moved across the worksurface using neither legs nor wheels but some kind of articulated toothed sprockets which adhered to the surface.

Whatever it was, it crawled its way over to where my half-finished device stood quiescent and then started to climb, the same sprocket wheels extending more and longer teeth for extra grip. It reached the section I was in the process of assembling. It froze, apparently studying what I could only think of as its target.

I dragged my attention away from the screen for a moment and pressed the button which started the high-resolution scan, just in time to capture the thing's head split open and whatever was inside starting to dissolve my newly created component. The device's head was dissolving too, whatever engineered macromolecules within tearing apart both itself and its target.

It was clear that the ellipsoid nanodevice must be one of billions, trillions, no, **nonillions** of such things - as numerous as viruses, at least - which infests every part of our world; otherwise it would be statistically infeasible that one just happened to be within a fraction of a micron of the device I was trying to make in my vacuum chamber.

As a scientist, my reactions were torn: on the one hand, it was a beautifully articulated device, perhaps half the size of a typical virus, a masterpiece of nanoscale engineering: flexible, probably self-replicating in a way that even viruses cannot manage without coopting the biochemical engine of a much more complex organism - cells of one kind or another.

On the other hand, I felt genuine visceral horror at the thought that these devices, or something like them, were present everywhere in our world, presumably capable of disguising themselves as innocuous substrates, all kinds of surfaces: metals, plastics, the cell membranes of every part of my own body. Somehow, though, I had managed to trick one into displaying at least some of its abilities.

At the completion of the detailed scan, the SEM reverted automatically to low-resolution near-real-time images, just in time for me to see the mysterious nano-device explode into a cloud of simple molecules, exactly the kinds of things that the hard-vacuum pumps were designed to remove efficiently, leaving no evidence that it had been there at all, and taking with it a substantial fraction of the device I had been trying to construct. No wonder my attempts at fabrication had been unsuccessful: something out there was actively preventing exactly such a development.

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I pulled up the high-res image and sat staring at it for a long moment, my head in my hands. My scientific training told me that I should attempt to reproduce the experiment, although I already suspected I knew the answer to that. I printed out a paper copy - sometimes these things are easier to study in detail on paper - as well as pored over the electronic version at as high a magnification as the number of pixels would allow. The section where the thing's head was 'eating' my device was blurred by movement, where the macromolecules were bending and stretching even as the SEM did its scan.

It was time to call upon the antique communication mechanism known as 'electronic mail', a medium which has been around since the dawn of the network age. Despite there being any number of more sophisticated communication capabilities available, it is still the go-to protocol to communicate with almost anybody on the planet, or off it, at least as far out as the asteroids.

I started to compose an email to Ted and Ken. Our orbital habitat runs on Hawaiian time, naturally enough, but Ted and Ken's locations are on the far side of the Pacific and three or five time zones behind mine, so it would still be daylight for them. I was not sure what to write at first, but in the end opted for attaching the high-res image I had captured, adding simply 'You're not going to believe what I've just seen'.

The responses were not long in coming. Ken's answer was an ironic 'Oh, I think I will', attaching another high-res image. Before I could even open the attachment, a second email arrived from Ted. 'Oh my god!' he wrote, 'What the hell is that thing? And how did it get there?' I shook my head: I wished I could answer those questions.

I opened Ken's image attachment. He too had managed to capture a high-res SEM view of some unknown thing again eating a partially complete nano-device, presumably in his own vacuum chamber. It was superficially similar to the one I manged to image, but there were differences: it used toothed sprockets for locomotion, but they were narrower and larger in diameter than the ones I had seen in my own view. The body in Ken's picture was slightly boxier, but it still had the same spherical head at one end as my version.

I wrote more email to Ken and Ted. 'I have no idea what they are. Some speculations: they are a sophisticated nanoscale technology specifically aimed, it seems, at preventing the development of any other nanoscale tech. I strongly suspect they are everywhere, in huge numbers, and therefore they must be capable of reproducing, perhaps self-replicating. I have no idea where they came from, or when they appeared.'

Ted's return email simply said: 'Okay. What do we do now?' Ken's response was pragmatic: 'We should replicate these results as many times as we can. just in case this is some kind of imaging defect or weird side-effect. Then alter the experimental conditions and see if we can change the behaviour. Oh, and they need a name.'

I thought for a moment, then typed rapidly: 'How about Nano-suppressors?' This met with immediate approval from Ken and Ted.

The next few weeks were very busy. All three of us were able to reliably reproduce the results many times in our own labs; nothing we tried seemed to prevent the appearance of a Nano-suppressor at the same point in the build process. We even tried shipping partially complete devices from one laboratory to another, in a evacuated flask, and restarting nano-assembly in a different vacuum chamber. There was a certain amount of fiddly complexity in aligning one partially built device with the electron beams in the other chamber, but the nett result was the same: a Nano-suppressor emerged and ate the guts out of the device.

We kept our discovery to ourselves for this period but something like this could not be kept secret for very long. We communicated - by email, mostly, variable orbital delays tended to make real-time audio or video teleconferenced jittery - and speculated on the origin of the Nano-suppressors. Were they some naturally evolved life form just waiting for other nanotech to emerge? Or some human agent determined to prevent nanoscale devices from becoming widely available? Are they an attack from those Expansionists - something they have left behind to hinder us? None of us could imagine that any of these proposals could be true.

'There is another possibility,' Ken wrote in one email exchange, 'They could be the work of non-humans, genuine intelligent aliens, who want to hinder our development, to limit the things that we, the human race, could do'. I found this suggestion chilling, but difficult to argue against as a hypothesis.

'It is time,' I sent in email, 'We are going to need to talk to our respective University's ethics committees. We cannot put that off any longer.' The others agreed; we all knew this day was coming. I composed a formal email to the University of Hawaii's committee, requesting a meeting and 'guidance on the publication of unexpected results'. Then I set about assembling the mandatory lengthy slide deck which such discussions seem to demand.

A week or so later, I found myself standing in a boardroom in front of five senior and august personages, all but one of which were physically present. Such persons are supposed to be independent of the University proper, although I am sure that one person was a Professor Emeritus from the Faculty of Science. I started my pitch; there was an audible gasp when I showed the first of several high-res images of a Nano-suppressor at work, followed by grainy images of the things moving about. I finished my slides with a heartfelt but open-ended request for guidance.

The panel chairperson looked at me sternly over steel-rimmed glasses. "This is not a joke, a prank, some kind of a hoax?" she demanded.

"No Ma'am," I replied promptly, "Quite definitely not."

"And you believe this might represent some kind of attack?" she pressed.

"Well, 'believe' is too strong a word," I answered carefully, "But I have difficulty in understanding how these Nano-suppressors are anything other than the result of intelligent intent." I did not actually mention aliens - I thought that was a step

too far - although I did stress that these results had been reproduced in other labs elsewhere on and around the planet.

The chairperson glanced at her colleagues, including the one of the screen in front of her. I could see the faintest of nods in the room; presumably there was one of the screen too.

"Doctor Momoa, I need to ask you to step outside for a few minutes," she said firmly. I moved to comply, folding my laptop and stepping back through the door. I was only outside for a minute, then I was summoned within.

"Doctor Momoa, thank you for coming to see us today," the chairperson said, with marginally more warmth than before, "I have to tell you that we are recommending the involvement of government agencies, security services, given the potential threat your discovery implies. So, I suggest you gather whatever it is you think you need for an extended trip and be ready to leave within the hour."

I was too shocked to say anything other than: "Yes, Ma'am."

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So, I began my involvement with the murky world of military intelligence. It was not immediately clear exactly what my status was: not really a prisoner - no chains, no locks, and an official pass which would allow me into at least some areas - but I could not leave, could not communicate externally without both permission and supervision, and an expectation that I would answer any questions I was asked.

I did not know exactly where I was, either, although it was definitely in space - the slight variations in gravity which is imparted by a large spinning structure were unmistakeable - as well as the trajectory of the windowless shuttle which brought me here. Also, I had no contact at all with any friends or colleagues, including Ken and Ted; I suspected that those two were undergoing similar treatment elsewhere.

Over the first few days, I was asked to go over what I had discovered, several times with several different audiences, at least one of which included somebody with a decent working knowledge of the state of the art in nanotechnology, and another who had little understanding of the technology, but was much more focussed on who might have the political will and the technical ability to pull off such a feat.

I had not mentioned the possibility of genuine aliens being behind the Nano-suppressors, although I was soon tackled on this point by somebody who had closely reviewed the email exchanges between myself and Ken. "Well, logically, his hypothesis is consistent with the evidence," I said reasonably, when challenged, "So it would be an error to exclude it as a possibility. But there's no positive confirmation for it and, in the absence of any other evidence for the existence of aliens, it remains pure speculation." My anonymous questioner went very still and silent at that point, and rapidly wrapped up that particular interview.

I was asked - not that I really had a choice - to attend an interview with an arrested Expansionist sympathiser, a woman called N'kone Memetja. I had read

somewhere that the Expansionists had a policy that, since their interstellar ships started departing and there was nothing anybody could do to stop them, of answering all questions put to them fully and honestly. Ms. Memetja still resided in a prison cell, of course, and in orbit - which was supposed to reduce the likelihood of escape - but not a particularly uncomfortable one, more like a room in a medium-standard hotel, although with less choice of room service.

After another orbital trip in another windowless shuttle, and an interminable walk through kilometres of corridors of grey lunar concrete in the company of a nameless guide, I was introduced to the lady herself. In person, she was a slender woman with long braids, with a piercing gaze and intelligent attitude. I was encouraged to sit across a desk from her, without the kind of handshake greeting that I might have expected and asked to tell her all about my discovery.

I talked briefly about my background, and the nature of the work I was undertaking, or trying to. I showed her pictures of the Nano-suppressors in action and explained in some detail what they were capable of; her face was a picture, horrified and disgusted in equal measure.

When I had wound down, my guide asked her: "Did the Expansionists, to your knowledge, create these things?" She shook her head firmly and said, "No. We concentrated our efforts on super-strong bulk materials, carbon nanotubes and the like, to make spaceships. Nothing this intricate. Or destructive."

As my guide and I were preparing to leave, Ms. Memetja asked a question which was quite definitely not in the script: "Is this to do with the evidence of aliens amongst us? Influencing everything? Controlling everything?"

I cannot describe the shock and horror I felt, even as I was hustled out of the interview room and down the concrete corridors at a quick march. My guide refused to answer, or even acknowledge, any questions, even when I was firmly strapped into the shuttle for the return trip. Those few words from Ms. Memetja had flipped Ken's hypothesis from speculation to certainty in my head; as I sat stewing in my own thoughts, I wondered about what other alien influences there might be.

The shuttle's engines lit up with a roar, the acceleration pushing me back into my seat as the engine thrust exceeded the compensation available from the inertial suppressors. This triggered a thought: our inertial suppressors - artificial gravity, if you like - are limited to three-and-a-bit gravities, limiting the maximum speed that spacecraft can achieve even when crewed by trained astronauts in high-G suits. But when those Expansionists lit up their interstellar craft in the Oort Cloud, they were accelerating much faster than that - twenty or twenty-five G, or even more. Somehow the Expansionists who had escaped from the Solar system had managed to avoid that particular limitation, perhaps simply by having run away before the whatever influence the aliens could exert, leaving us left behind trapped in a single stellar system.

The very best zoos do their utmost to avoid making the enclosures too obvious to the creatures so contained. The people living on and around Earth - like me, for example - were quite used to working with technology which was well-developed

by the middle of the twenty-first century, with nothing radically new being developed since then.

I was suddenly sure I was not going to be allowed to tell anybody about all this.