Science and Technology

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On June 5 2021 tardigrades arrived at the International Space Station as part of NASA's 'Cell Science-04' experiment studying how tardigrades adapt and thus survive in high-stress environments such as cosmic radiation and extreme dehydration (NASA Science, 2021). Researchers hope the results will offer methods for protecting humans from long-duration space travel. In 2007, the European Space Agency's (ESA) 'Tardigrades in space' (TARDIS) experiment tested their capacity to survive in space, but this new experiment directly and eerily connects to the fictional science cultures of *Star Trek* (*ST*), particularly *ST: Discovery*. *Discovery*'s first season incorporates a 'giant space tardigrade' named Ripper.[1] As Michael Burnham (Sonequa Martin Green) explains, Ripper can 'incorporate foreign DNA into its own genome via horizontal gene transfer. When Ripper borrows DNA from the mycelium, he's granted an all-access travel pass.' Although this process is scientifically inaccurate, it still helped to elevate common knowledge of the tardigrade from Internet meme to a more generally recognisable animal.[2] The tardigrade became the subject of various explanatory articles thanks to *Discovery*'s fictional interpretation of its unique real-world genetic properties in propelling both the show's narrative and its spore drive (Kim and Wong, 2021; Fullerton, 2019; Blaxter and Arakawa, 2017).

This chapter presents the science and technology of *ST* 'within a cultural framework' that considers science as 'a genre, theme, or conventional representation in fiction' (Kirby 2003: 263), rather than a reductive focus on scientific accuracy and the transition of technology from fiction to fact. *ST* has offered one of the most consistently positive images of not only science but also scientists across the decades since its inception. The role of science in *ST* is a formative cultural structure that inspires not only how the stories progress but also how the universe of the franchise has been imagined and reimagined in responses to changes in scientific knowledge, as well as public understanding of and attitudes to the sciences. *ST*'s imagined future is one where advances in science, technology, engineering and mathematics (STEM) have led to the post-scarcity utopia where material goods, essential

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[1] Ripper appears in *ST: Discovery* episodes: 'The Butcher's Knife Cares Not for the Lamb's Cry' [1x4], 8 October, 2017; and 'Choose Your Pain' [1x5], 15 October, 2017.
[2] As a conduit for a form of advanced instantaneous interstellar transportation *Discovery*'s use of the tardigrade has been criticised by a number of scientists. As Prof. Steven Saltzberg (2017) remarks: 'using horizontally transferred DNA for space travel is so nutty, so bad, that it's not even wrong. Even if tardigrades could absorb foreign DNA (they can't), how the heck is this supposed to give them the ability to tap into the (wildly implausible) intergalactic spore network?'

services and information are universally accessible. But this is still framed as a technological future that is earnt rather than given, with primitive societies left to develop and discover their own innovations without the interference of Starfleet and The United Federation of Planets. This reflects an understanding on the creators' part—and an attempt to convey and instil that understanding in their audience—that science and culture are inextricably bound. From communication media to weapons to medicine, the central discourse of *ST* is how a society achieves its scientific breakthroughs and uses the resulting technology, for good or for ill, for the one or the many.

The following sections explore this discourse, and the arguments it makes about *ST*'s role in our own modern culture of science and technology, but also how the fictional world mirrors and interacts with culture. The first section introduces *ST* as a fundamental communication of STEM to the public, showing what is imagined, what is possible, and what might, in some cases, someday be achievable. Section Two explores the storyworld of *ST*, and how its premise of a post-scarcity utopia is based upon its central, and perhaps most unachievable, fictional technologies. This is followed with a darker dive into the cautionary messages the franchise conveys about science, technology, and responsibility, as we look at other technologically-advanced cultures within the storyworld whose cultures have been shaped from different foundations, such as those of the Borg and the Mirror Universe. Finally, we focus on the networks of science and technology, and how *ST* tests the tension between the biological machine that is the body and the abstraction that is the self, addressing increasingly complex questions of medicine, speciation, gender, sexuality, and emotion.

Public Understanding of Science and *Star Trek*

C.P. Snow (1959) argues that there is a fundamental gap between the spheres of knowledge of the humanities and the sciences—a gap that positions them as separate and even opposed cultures. Science fiction (SF) is a space that integrates science and culture/society into mutual interaction and inspiration, a 'mode of perception that holds open to question new technological things and scientific ideas' (Chambers and Garforth, 2020: 247). The genre was the first to 'devote its imagination to the future and to the ceaseless revolutions of knowledge and desire that attend the application of scientific and technical knowledge to social life' (Csicsery-Ronay, 2008: 1). Science on screen, page, and stage can have a direct influence over how people understand scientific ideas, practices and ethics, which can in turn affect policy decisions, attitudes to 'real world' science, and future scientists who have consumed and been inspired by scientific fictions. As the original series (*TOS*) creator Gene Roddenberry adroitly explained: '*Star Trek* started with the premise that the American television audience is a lot more intelligent and perceptive than the so-called "experts" insist'

(1966: np). In SF we can locate a 'mix [of] scientific knowledge with fictional techniques' that does more than simply show images, as it offers 'an important space where the construction and constitution of science is negotiated' (van Dijick, 2003: 183). Science and entertainment are two of the major ways that humans understand their world, and SF works through scenarios and consequences that place science within recognisable and projected ethical and moral frameworks.

From automatic sliding doors to communicators and smart phones to replicators and 3D printing, *ST* has imagined science futures as part of a complex narrative world that not only presents new technologies but also 'calls up altered worlds and futures as creative spaces of exploration, speculation, and negotiation about and with science' (Chambers and Garforth 2020: 248). It provides a narrative space for reflecting on not only advances in STEM but also considering their impact on human action and social structures. The *Discovery* crew use their tardigrade as a navigation mechanism; the narrative arc, however, also considers the animal as an embodied subject. As she petitions for the creature's release, Burnham notes that using Ripper for the spore drive is both 'unsustainable for the creature and your invention'. Science is not outside of the culture we live in and consume but part of it; interactions with science are not limited to the lab but found across culture. Throughout its history and various instalments, *ST* acts as a historical record of public understanding of science and cultural responses that move us closer to the very future the series imagines.

SF and especially culturally embedded cross-platform franchises like *ST* perform an important function in considering what might happen if we fail to consider the consequences of our emergent science and technology. Scientific progress does not exist in a vacuum; it 'is produced by, and in turn shapes, a contingent malleable, complex social world' and thus it is inextricably linked to the culture that developed it (Vint, 2014: 314). But where many other SFs imagine the worst-case scenario—e.g., the Alzheimer's cure prematurely released in *Rise of the Planet of the Apes* (2011) that decimates the human race—*ST* since its launch in 1966 has offered broadly positive visions of the future, and crews of explorers and scientists benefiting from and promoting the utopian possibilities of science. And though some of the speculative science on *ST* has been transported from fiction to fact, we do not live in a technological utopia. The series itself recognises that technology *alone* neither causes utopia nor apocalypse, as the Prime Directive forbids Starfleet members from using their technology to interfere with the internal and natural development of alien civilisations, even if they would save lives or propel a community into a 'better' future. Science and technology are knowledge and tools; it is the people and culture in which they are embedded that shape how they are used in the actual world.

Framing and Accepting the Other: Scientific Utopia

In the *ST* universe the Federation trains young explorers and sends them out on missions in a post-scarcity utopia brought about by significant technological advances. Wealth is no longer necessary or valued, and necessities including food and healthcare are universal. In *Star Trek: The Next Generation* (*TNG*) Season 1, Captain Jean-Luc Picard (Patrick Stewart) explains to a 20th century man awakened in the 24th century:

> A lot has changed in the past three hundred years. People are no longer obsessed with the accumulation of things. We've eliminated hunger, want, the need for possessions. We have grown out of our infancy.[3]

Capitalism is relegated as an embarrassment of primitive society, or recalcitrant civilisations such as the Ferengi (who appear most frequently in *Deep Space Nine*), whose alternate use of Federation technologies illustrates the importance of framing and understanding technologies with reference to the cultures that use them. The Federation's post-scarcity utopia remains contingent on its power (including military technologies) to maintain its ideological structure despite the influences and threats of other violent, misogynistic, racist/speciesist, and capitalist societies.

First Contact (1996) establishes 2053 as the Federation's inciting incident: the global nuclear holocaust of Earth's World War III. As few governments remained afterward, this devastating event necessitated the world to be rebuilt, but also offered an opportunity to reimagine the world's socio-economic structures and systemic failures. In this freewheeling post-bellum era, Dr Zephram Cochrane (James Cromwell) and his team of engineers developed the warp drive, which not only introduced faster-than-lightspeed propulsion but also brought Earth to the attention of the Vulcans. STEM propels again not only the characters but also the narrative, as the Vulcans recognised that humans would soon become more than merely inhabitants of an isolated backwater. Thus, Earth became, through this technological advancement, a possible threat to the rest of the known universe.

Two key technologies serve Starfleet's mission to exchange knowledge and peace with other sentient species: the warp drive, and the universal translator (UT). The warp drive, as noted, was the instigating factor bringing humans into contact with other races. The UT enabled the ships' crews to be able to speak to these civilizations once they arrived; this often overlooked technology is a staple in SF, from Douglas Adams' babelfish to *Farscape*'s

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[3] 'The Neutral Zone' (1x26), 16 May 1988.

translator microbes.[4] *Enterprise*, *TOS*, and *Discovery* depict the UT in a very familiar manner to contemporary smartphone users: communicators served as a basic Google-Translate-like interpreter. While the devices got the essential job done, xenolinguistic specialists like Nyota Uhura (Nichelle Nichols) and xenoanthropologist Michael Burnham—notably both black women working in STEM—were required for nuance and diplomacy (Chambers, 2020). By the time of *TNG* and *Voyager*, the UT had been embedded into the crew's comms badges, and linguistic specialists were largely superfluous—enter Deanna Troi's (Marina Sirtis) *TNG* role in aiding communications and negotiations through her Betazoid 'psionic' ability to detect emotions. Although problematically her communicative skills are used in the service of men: Deanna uses her expertise and voice to 'allow for men to communicate' (Roberts, 1999: 69). The ability to travel to meet new species, to communicate with them for trade, resource, and knowledge exchange: these are used for the purposes of peacemaking and diplomacy in the idealised world of the United Federation of Planets.

These technologies, and indeed the Prime Directive, also demonstrate a key tenet underlying the *ST* universe: acceptance of the other. As Anne Cranny-Francis (1998: 70) explains, technology in *ST* operates 'as a signifier of difference—of the possibility of new perspectives and new ways of thought'. That difference, though historically framed through fear in many alien-based narratives, is approached from another angle in the *ST* universe. Though many storylines are constructed around humans' initial failures to accept the beings they encounter, most resolve with a burgeoning understanding and acceptance of difference. Every effort is made to reduce the distance between the known and the unknown, from the warp drive (and other space travel technologies like spore drives and wormholes) that enables planets to become neighbourhoods, to the translators that permit interspecies communication, trade, and diplomacy, to the entertainment technology. The emergence of replicator, Holodeck, and android technology in *TNG* reflect a late 20th century optimism about the civil and women's rights *TOS* had so often provided commentary on, in that they move the unknown other from a difference in skin or gender to one of mechanical (or cyborg) origin. In our post-Cold War age, our fears become wrapped in questions of resources and machines, food and artificial intelligence, stagnant birth-rates and overpopulation. These technologies help us to imagine the societal and interpersonal effects of daily interactions and immersion in the mechanical and the virtual.

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[4] Despite ancient languages being key to the storyworld of *Stargate*, its TV series is one of the few that simply shrug off the notion of incompatible linguistics.

The most representative technology of this post-scarcity utopia is the replicator, which appears in *TOS* as a 'food synthesizer' that can convert proteins into edible cubes; it is in *TNG* that the replicator earns its name, however, and demonstrates its power. The replicator converts energy into matter, whether the matter required is air, a new uniform, or 'Tea. Earl Grey. Hot.' With this technology, resources are no longer subject to disruption, and the Federation can not only trek to the far reaches of space, but also break free of resource-driven economies and conflict. This underlying scientific principle of mass-energy equivalence (i.e., Einstein's $E = mc^2$) provides the foundation for the replicators, as well as holographic technologies such as the holodeck and emergency hologram (EH) crew members. Not only is *ST* society free from *resource* scarcity with these technologies, it can also be free from *human* resource and knowledge scarcity.

The Holodeck creates simulated experiences of worlds, and even characters, beyond the confines of starships on ongoing missions. In *Picard* the technology is used to create interactive emergency holograms (EHs) aboard the ship *La Sirena*: engineering (Ian/Scottish), tactical (Emmett/Spanish), hospitality (Mister Hospitality/American), etc… . These EHs are all played by Santiago Cabrera, who also plays the ship's human Captain Cristóbal Rios. These EHs aid Rios in running and maintaining his ship in lieu of a physical crew. The EHs are not new: an emergency medical hologram (EMH) clinically named The Doctor (Robert Picardo) appears most memorably in *Voyager* (Grech, 2020), where his character arc expands from programmed medical aid to a fully realised sentient being with desires and emotions. *Picard*'s EHs are a logical culmination of similar character journeys, having developed distinct personalities and accents, and (often over-) anticipating needs: raised blood pressure summons the EMH that can also replicate supplies on the spot, and a homesick guest instantiates Mister Hospitality and his holographic replica of Picard's home office. These EHs reflect changing public responses to virtual assistants and their increasing presence in our lives. Just as we can see the changing faces and forms of medics in the ST universe as a response to changing expectations about the futures of doctors and medical care (Grech 2020), we can see in *ST* the notion that having worth is more about knowledge, skills, and contribution, than it is about having a specific shape, colour, type (or even any) of body: humanity can be enhanced by technology, but not erased. This cyborgian philosophy establishes the essential worth of every sentient life, whether biological, mechanical, or somewhere in between, and creates a template for peace in its aggressive acceptance of the Other.

Data (Brent Spiner) provides an embodied representation of this philosophy, though he is an android, and cyborg only in the sense that his sentience, sense of self, and his desires

express an intangible humanity amidst his artificial circuitry. His purpose in the storyworld is abundantly clear in every action he takes, every arc centred on his character: to question what it means to be human. If we can accept a Klingon on a Starfleet bridge, can we accept an AI? *ST*'s idealism about what it means to be human—to be generous, inventive, loyal, moral, and even heroic and self-sacrificing—is put to the ultimate test in Data, in which such illogical emotions boil down to conditionals in an algorithm in his memory chip. Of course, he is embodied in the form of a white-aligned, heterosexual (evidenced by his physical relationship with Tasha Yar [Denise Crosby]) male, as most media androids are (Carper, 2019), which goes a long way toward acceptance in a Western society that continues to place premium value on representations of the patriarchy (Manne, 2017). *Picard*'s season one story arc pushes this question forward: despite Data's success, androids are outlawed, hunted, and destroyed. Humans fear now, more than ever before, the other as represented in human-created code, after decades of social media hacks, identity theft, Internet scams, and cyberattacks. Yet, the same technology that creates the fearsome fictional future capabilities of Data and his kin enhances actual living for many, including prosthetics and pacemakers. Picard's (both the show and character) stance against the ban on androids reinforces the *ST* universe's position that STEM has no inherent morality; it is through their use and incorporation into lives and bodies that they gain an ethical or political reading.

Cautionary Tales

Though *ST* is certainly held up as a utopian ideal achieved through advanced technology and science, it also explores narrative arcs involving clashing ideals, battles, and war. The Klingon society provides a strong foil to that of the Federation, as their primary purpose for STEM is not for knowledge and exploration but for conquering and war. The Mirror Universe, introduced through a glitch in the fantastical transporter technology, is a direct reflection of the *ST* universe had humans embraced a warlike society rather than a peaceful one. As a SF trope it invites 'audiences to interrogate the social orders presented as normative in the previously established fictional prime [universe]' that offers an image of unregulated science and questions the true intentions of the Federation beneath its utopian veneer (Bryne and Jones, 2018: 257). Starfleet is not only a science diplomacy group—it is also a military organisation, with all the trappings of such: ranks, orders, training, weapons. Finally, the Borg represent the extreme of technology, when what is human is lost; as it is introduced in the same series as Data's on the bridge of the *Enterprise* (*TNG*), it and other AI-related disasters provide a cautionary foil to the utopic notion of mechanical benevolence.

Belying their message of exploration and diplomacy, all ships in Starfleet are armed with weapons (photon torpedoes) and shields. In actual-world equivalencies, scientific missions

are not typically conducted on naval gunships, though they may include weapons for procuring food or defending against wild animals. Starfleet Academy as shown, likewise, places far more emphasis on its lessons as a military training base than as a scientific university. Part of their mission is to discover new civilisations, ostensibly to monitor them and bring them into the Federation fold when ready. It offers a benevolent sort of cultural imperialism, and human history teaches us these interactions are fraught with violence. The Federation is frequently at war—with Klingons, Cardassians, Romulans, the Dominion—and despite its stated scientific mission, the *Enterprise* is also the 'flagship' of the Starfleet military. Given our human history, perhaps we cannot imagine or relate to a world in which meeting new civilisations or trading for newly discovered resources is peaceful, thus necessitating the convergence of science exploration with war. *ST* presents a 'complex constitutive tension between scientific exploration and defence' (Weldes, 1999: 132), but often skirts this problematic depiction of Starfleet, positioning the weapons as defensive (and at times, used for alternative methods such as mining), implementing a 'talk first, shoot second' philosophy, and banning the more offence-oriented technologies such as cloaking devices used by warmongering civilisations Klingons and Romulans. These narrative loopholes attempt to place the Federation and Starfleet in a morally superior position, valuing diplomacy and communication over violence, and openness over stealth. Yet the blue-sky thinking in terms of this technological utopia did not go so far as to imagine a universe in which *humans* are not the morally superior species, and in which weapons and military tactics are symbols of immaturity rather than power.

Digging more deeply into this question of humans as harbingers of peace or war is the recurring theme of the Mirror Universe. The *ST* Mirror Universe is initially reached in *TOS* thanks to a glitch in transporter technology,[5] a fictional representation of the scientific theory of a quantum universe, which posits parallel universes as an explanation for anomalous behaviour of electrons under observation. In each series/film in which the Mirror Universe appears (*TOS*, *DS9*, *ENT*, *Discovery*), the storyworld and its characters are antithesis to those of the Prime Universe: Kirk is cruel and selfish, Bashir is irritable and tempestuous, Kira is a ruthless hedonist, Burnham is bitter and violent, and Georgiou is a power-hungry empress holding her throne (against surrogate daughter Burnham) through fear, aggression, and manipulation. Instead of the tenuous peace engendered by the Federation in the Prime Universe, the Mirror is dominated by the Terran Empire borne of fascism, fear, aggression, and violence. The major historical events, such as First Contact with Vulcans, are intact, yet

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[5] In terms of the ST storyworld timeline, the Mirror Universe appears to have branched off from the Prime Universe as early as 1955, based on events in episodes of *Enterprise* and *Discovery*: 'In a Mirror, Darkly' *Enterprise* (4x18), 22 Apr 2005; 'Vaulting Ambition' *Discovery* (1x12) 21 Jan 2018.

because Terrans are so deeply wedded to empirical ideals of force, the technology is used for domination and aggression rather than exploration and knowledge (Buzan, 2010). The Mirror Universe is perhaps a more accurate reflection of our actual world than the Prime Universe, providing a foil for which the Prime Universe offers hope of avoidance.

If the Mirror Universe presents a dystopic alternative for our technological future, the Borg present the ultimate expression of our (perhaps legitimate) fear of technology. In the wake of World War II and the Cold War, surveillance culture, AI, and our increasing dependence on technology, we question what it is that makes us human. As neoliberalism metastasises throughout Western culture, the notion of individual freedom reigns supreme: free enterprise, free choice, free movement, free speech, free will. Moral panic over technology, from robot workers to drone weapons, as well as the oft-exaggerated parallels between hard drives and the human mind, result in the ultimate 'baddie': the Borg. As Juli L. Gittinger (2019: 66) notes 'the Borg may have proceeded Web 1.0... but their posthumanism has certainly realized these anxieties and critiques of our technological selves'. The Borg is referenced when new implanted technologies are discussed—e.g., brain-machine interface (BMI) research conducted by Elon Musk's company Neuralink—as we consider whether implanting technology into our bodies is the first step towards assimilating into the billionaire's Collective. Data, though entirely artificial, actively pursues the question of humanity throughout *TNG* and related films, seeking to enhance his mechanoid nature by immersing it in the intangible qualities of humanity: emotions, friendship, caring, humour. The Borg, in contrast, seek to overcome the perceived weaknesses of humanity by converting flesh to machine, and removing all individuality. In a *ST* society that embraces essentially socialist practices while retaining value in personal achievement, the Borg represent the ultimate in technocracy: complete loss of individuality to serve a single monarch, for no other purpose than relentless acquisition. Comparisons can also be drawn to our ever-expanding wealth gap, to the billionaires and people of power who exploit the masses as drones even as they exponentially assimilate more wealth and power through technology. Technology, after all, does not create itself, even in Borg cubes: at the core of each is a Zuckerberg, a Musk, a Bezos, Queens of their own capitalist collectives. As freed Borg drones Seven of Nine and Icheb demonstrate, technology itself does not make one a monster; it is how it is used that renders it either benevolent or malevolent.

The Body as Host
The Borg's extension of technology as something that can not only enable human activities but enhance and even rule over the body introduces an important aspect of *ST* science and technology that is often overlooked in favour of whizzy gadgets and engineering: body

modification. The *ST* universe 'interrogates the politics in envisioning, and potentially creating, an alternative future, especially for those who have traditionally been left out from dominant imaginaries' (Song and Tan, 2020: 579). The franchise's incorporation of diverse crews and alien forms allows for discussion of identity and the changing techno-futures of what it is to be human. Historically, racist narratives have presented the 'one-drop' definition, wherein one metaphorical drop of the other renders one's humanity null and void (Nama, 2008, 43-69). But in the *TNG* episode 'The Chase' (6x20) the humanoid races in the galaxy are established as genetic cousins, seeded by ancient sentient and shared ancestors called the Preservers. Building upon the panspermia concept (the transferral of viable organisms between planets seeding similar species), *ST* imagines a universe where similar plants, animals and humanoids developed on a variety of worlds across billions of years of evolution. These bipedal humanoids are not simply alien others or even contaminated by something other than human, but rather evolved from the same genetic starting points. This is utilised narratively to explore the different facets of humanity and evolving attitudes to the complexity of human identity: the Vulcans' intelligence, Klingons' aggression, Betazoids' empathy, Trills' adaptability.

The Trill most explicitly express the queer nature of science as a potential process of deconstruction and denaturalising, as emerging discussions of STEM consider 'the multiple bifurcations of self, time, and space required to simultaneously navigate queerness and STEM' (Friedensen, et al., 2021: 341). The Trill enter into a symbiotic relationship with a second non-humanoid species, literally becoming a mix of two beings; gender, race, embodiment, memory, and identity all become blended and mutable. Further, the symbiont retains the memories from all of its previous hosts; thus, the boundary between self and other is fluid and becomes a collective experience where skills, memories, emotions and lives are shared without restriction across hosts both living and 'dead'. In *DS9* Trill science officer Jadzia Dax's previous host was male; *Discovery* introduces the franchise's first non-binary and trans characters. Non binary human Adira Tal (Blu del Barrio) becomes the first non-Trill to host a symbiont after their trans Trill lover Gray Tal (Ian Alexander) is killed and Adira is the only available host for this endangered species. But in becoming part of the Tal symbiont, Adira eventually becomes part of Gray's memories and experiences. He lives on, saving not only the Tal symbiont but also his and Adira's connection. This merged embodiment is seen as a positive experience where Adira shifts from being only a they to a 'we' as they become part of a supportive multifaceted collective.

Seven of Nine represents another merged body, as one of three major women scientist characters on *Voyager*, and her position as Borg is considered one of her strengths. The

negativity of the Borg experience on the individual and the franchise as a whole is mitigated in this character. Three of *Voyager*'s major women characters work in STEM: Captain Kathryn Janeway (Kate Mulgrew), engineer B'Elanna Torres (Roxann Dawson), and science officer Seven of Nine (Jeri Ryan). Their perspectives are integral to the work they do and align with feminist science critiques that argue that an individual's social position and identity (race, gender, sexuality, ability, etc.) can provide insights and methods that those of other social positions might not consider (Naples and Gurr, 2013). Both Torres and Seven of Nine are marked as doubly othered as women in traditionally (and historically in *ST*) male roles and also as aliens: Torres is a human-Klingon hybrid and Seven of Nine retains some Borg biotech. By representing science and its advances through characters that are women *and* alien, the series highlights the importance of diversity in STEM and how this can positively affect progress. Seven regularly uses her Borg experiences and technology to develop and support the crew: for example, the astrometrics lab that uses Borg technology to plot routes and quicken their unscheduled journey through the Delta Quadrant.[6] Her non-human beyond-human perspective makes her valuable rather than presenting a barrier to participation. *Voyager* 'resists and revises' stereotypes around what women can achieve as scientists and in their personal lives as these women do not 'renounce' their femininity following misogynistic ideas about successful women that are often found in male-written scientific fictions (Roberts, 2000: 280).

The more horrifying side of merged embodiment is explored through the Borg, and the characters who are able to regain their humanity after leaving a Borg hive: Jean-Luc Picard (*TNG*, *Picard*), Seven of Nine (*Voyager*, *Picard*), and Icheb (Manu Intiraym *Voyager*; Casey King, *Picard*). Unlike the Trill, no one joins the Borg by choice; it is a process that renders the individual mind and persona effectively dead, as the body is assimilated into a groupthink neural network. Borg do not replicate biologically. They merely consume, overpowering their victims and laying claim to whatever living bodies remain in the aftermath. Once assimilated, a Borg individual no longer has individual thoughts or actions; they are extensions of the Borg Queen, acting on her impulses, one of many thousands of drones. They are not male or female, do not have emotions or desires, and are entirely expendable both to their hive and to themselves. For Picard, who had lived a lifetime as a human with free will, the experience of being assimilated as Locutus of Borg even for a short time was intensely dehumanising, leaving him with echoing trauma. For Seven and Icheb, both assimilated as children, the reverse was true: becoming individuals was isolating, terrifying, and lonely.

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[6] The astrometrics lab is updated and launched in: 'Repulsion' *ST: Voyager* (Ep 5, Season 4, NBC, 1 October 1997); and 'Year of Hell' *ST: Voyager* (Ep 8, Season 4, NBC, 5 November 1997)

The Borg also reflect fears about the literal and virtual integration of technology with the self. When *TNG* was on the air 'digitization and miniaturization were in full swing' (Ballard, 2015: np) and the Borg represented a future where technology was not simply carried on the body but became 'intertwined with the very flesh' of the user (Liberati, 2018: 45). *ST* is filled with wearable technologies that reflect changes in real world innovations and public expectations, such as communicator evolution from intercom in *TOS* to integrated transporter, communicator, and hologram computer access point in *Discovery*. As Nicola Liberati (ibid.) notes in her analysis of wearable tech through the eye of Borg futures, where is the point where the individual 'I' becomes part of a plural 'We-I' when it comes to reliance and inseparability from technology. Separation from technology in the Borg is often tantamount to or literally the cause of death, and our current use of wearable technology does not force us into the Collective as of yet. But as Liberati (46) surmises:

> The collective body generated by wearable computers will start to act in the world producing their own collective perceptions, their own collective actions, and their own collective needs just like the Borg Collective.

The advances in wearables and implantable bio-modifying technology has potential to create the hierarchical inequality, which is where SF plays a vital role in imagining the future applications and ethics of these increasingly possible STEM innovations.

Conclusion

In the months following *TOS*'s initial release, Gene Roddenberry (1966: np) argued that 'science fiction [was a] thing of the past' because *ST* was 'real adventure in tomorrow's space'. The show was supported by technical advisors, thus extending it beyond the SF of the 1950s and 1960s as it attempted to provide 'scientifically plausible speculation' rather than alien monsters and mad scientists (Allgaier, 2018: 85). Although *TOS* was created at the cusp of a dystopic cycle—e.g., *Planet of the Apes* (1968), *Silent Running* (1972), and *Logan's Run* (1976)—it maintained a utopian perspective while integrating many of the same issues including civil rights, second-wave feminism, and nuclear disarmament. The engagement with science advisors drawn from major organisations like RAND and NASA gave the show a legitimacy and also a reciprocal relationship with those major institutions that recognised the power of popular science communicated and diversified through fictional but widely accessible media.

ST not only imagines future technologies, but also their cultural and social impact in a world that is not automatically dystopian. The technological imaginary is the basis for the social imaginary; they coexist, and advances in either are entwined with or caused by the other. Imagining radical, innovative, and potentially post-Capitalist science and technology should come with a consideration of how it will coexist and cooperate with humans and our environments. *ST* engages with the 'utopian method' that 'aims to change and not simply know the world' (Moylan, 2007: 204). It offers solutions and an imagined space where advances in STEM are not automatically used to create further divisions between the haves and have-nots. Although the *ST* universe in its development over nearly 60 years has seen the inclusion of black ops and dystopic mirror universes, it does so to encourage us to imagine STEM's viable 'transformative possibilities' (Moylan, 2007: 213). Science is power, science is political, but it does not always have to be imagined as inevitably apocalyptic.

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