


Please cite the Published Version

Chambers, Amy  and Skains, R Lyle (2022) Science and technology. In: The Routledge Handbook of Star Trek. Routledge Literature Handbooks . Routledge, pp. 348-356. ISBN 9780429347917 (ebook); 9780367366674 (hardback)

DOI: <https://doi.org/10.4324/9780429347917-53>

Publisher: Routledge

Version: Accepted Version

Downloaded from: <https://e-space.mmu.ac.uk/628273/>

Additional Information: This is an Accepted Manuscript of a book chapter published by Routledge in The Routledge Handbook of Star Trek on 21st July 2022, available online: <http://www.routledge.com/9780367366674>

Enquiries:

If you have questions about this document, contact openresearch@mmu.ac.uk. Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)

Chambers, Amy C., and R. Lyle Skains. 2022. Science and Technology. In *The Routledge Handbook to Star Trek*, edited by Leimar Garcia-Siino, Sabrina Mittermeier, Stefan Rabitsch, chapter 47. New York: Routledge.

47. Science and Technology

Amy C. Chambers and R. Lyle Skains

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 survive in high-stress environments (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 'Tardigrades in space' (TARDIS) experiment tested their capacity to survive space, but this new experiment directly and eerily connects to the fictional science cultures of *Star Trek*, particularly *DSC*. *DSC*'s first season incorporates Ripper, a 'giant space tardigrade'. 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" (*DSC* 1.05, 2017). 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 (see Ch 56).¹ The tardigrade became the subject of various explanatory articles thanks to *DSC*'s fictional interpretation of its unique real-world genetic properties in propelling both the show's narrative and its spore drive (Blaxter and Arakawa 2017).

This chapter presents the science and technology of *Star Trek* "within a cultural framework" that considers science as "a genre, theme, or conventional representation in

¹ Several scientists have criticised *DSC*'s "nutty" use of the tardigrade and horizontally transferred DNA for interstellar transport (Saltzberg 2017, np)

fiction” (Kirby 2003, 263), rather than a reductive focus on scientific accuracy and the transition of technology from fiction to fact. *Star Trek* has offered one of the most consistently positive images of science and scientists since its inception. *Star Trek*’s science is a formative cultural structure inspiring not only how the stories progress, but also how the storyworld has been re/imagined in responses to changes in scientific knowledge, as well as public understanding of and attitudes to science. *Star Trek*’s imagined future is one where advances in science, technology, engineering and mathematics (STEM) have led to a post-scarcity utopia. This environment, however, is still framed as a technological future that must be earned; primitive societies must develop and discover their own innovations without interference from Starfleet and the United Federation of Planets. This reflects an understanding on the creators’ part—and an attempt to instil that understanding in their audience—that science and culture are inextricably bound. The central discourse of *Star Trek* 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, the arguments it makes about *Star Trek*’s role in modern cultures of science and technology, as well as how the fictional world mirrors and interacts with those cultures.

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, positioning them as separate and even opposed cultures. The space of SF 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), that “attend[s] 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 Gene Roddenberry explains, “*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... where the construction and constitution of science is negotiated” (van Dijck 2003, 183). Science and entertainment are two of the major ways that humans understand their world, and SF scenarios and consequences place science within recognisable and projected ethical-moral frameworks.

From communicators and smartphones to replicators and 3D printing, *Star Trek* 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 considering STEM advances’ impact on human action and social structures. Ripper is the *DSC*’s navigation mechanism; the narrative arc, however, also considers him as an embodied subject. Burnham petitions for his release, noting his exploitation as “unsustainable for the creature *and* your invention”. Science is not outside of our culture but part of it. Throughout its history and various instalments, *Star Trek* acts as a historical record of public understanding of science and cultural responses moving us closer to the very future the series imagines.

SF and especially culturally embedded franchises like *Star Trek* perform an important function reflecting on the consequences of emergent science and technology. Scientific progress “is produced by, and in turn shapes, a contingent malleable, complex social world” and thus 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 experimental Alzheimer’s

treatment in *Rise of the Planet of the Apes* (2011) that decimates the human race—since 1966 *Star Trek* has offered broadly positive visions of the future, showcasing crews of explorers and scientists benefiting from and promoting the utopian possibilities of science. And unlike much of the speculative science on *Star Trek*, technological utopia has not been transported from fiction to fact. The series itself recognises that technology alone neither causes utopia nor apocalypse, arguing that 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 reality.

Framing and Accepting the Other: Scientific Utopia

Thanks to its post-scarcity utopia (see [Ch XX \[Utopia\]](#) for in-depth discussion), wealth in the *Star Trek* storyworld is no longer necessary or valued, and necessities including food and healthcare are universal. The Federation's post-scarcity utopia remains contingent on its power (including military technologies, see Chs 44 and 45) to maintain its ideological structure despite the influences and threats of other violent, misogynistic, racist/speciesist, and capitalist societies.

Per *First Contact* (1996), Earth's World War III incited a global nuclear holocaust, destroying world governments and offering 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 engineering team developed the warp drive, introducing faster-than-light propulsion. This attracts the attention of the more technologically advanced Vulcans, who recognise that humans have effectively entered the galactic neighbourhood, and present a possible threat to the rest of the known universe.

Two significant 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 speak to these civilisations; this often-overlooked technology is a staple in SF, from Douglas Adams' babelfish to *Farscape*'s translator microbes.² *ENT*, *DSC*, and *TOS* 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 Hoshi Sato (Linda Park) and Nyota Uhura (Nichelle Nichols), and xenoanthropologist Michael Burnham—notably all women of colour working in STEM—were required for nuance and diplomacy (Chambers 2020). By the time of *TNG* and *VOY*, the UT had been embedded into the crew's comms badges, and linguistic specialists were largely superfluous. 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 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 *Star Trek* universe: acceptance of the Other. Technology in *Star Trek* operates “as a signifier of difference—of the possibility of new perspectives and new ways of thought” (Cranny-Francis 1998, 70). That difference, historically framed through fear in many alien-based narratives, is approached more optimistically in the *Star Trek* 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 spore drive 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* reflects a late twentieth-century optimism about the civil and women's rights *TOS* had so often

² 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.

reflected, in that they move the unknown Other from a difference in skin or gender to one of mechanical (or cyborg) origin. In a post-Cold War age, social fears become wrapped in questions of resources and machines, food and artificial intelligence, stagnant birth-rates and overpopulation. These technologies help audiences to imagine the societal and interpersonal effects of daily interactions and immersion in the mechanical and the virtual.

The most representative technology of this post-scarcity utopia is the replicator, which appears in *TOS* as a food synthesiser 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 *Star Trek* 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 EHs aboard the ship *La Sirena*: Ian, a Scottish engineering EH; Emmet, a Spanish tactical EH; and Mister Hospitality, a North American hospitality EH, among others. These EHs are all played by Santiago Cabrera, who also plays the ship's human Captain, Cristóbal Rios. These EHs aid Rios in running 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 a medical program to a fully realised sentient intelligence (see Ch 57). *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 replicate supplies on the spot, and a homesick guest instantiates Mister Hospitality and holographic replicas including 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 *Star Trek* universe as a response to shifting expectations about the futures of medical care (Grech 2020), we can see in *Star Trek* 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—to be generous, inventive, loyal, moral, and even heroic and self-sacrificing. In Data, emotions, whether logical or not, boil down to conditionals in an algorithm in his memory chip (see Chapter XX [Posthumanism] for more discussion), rather than biology. Picard's (both the show and character) stance against the ban on androids reinforces the *Star Trek* 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 *Star Trek* is certainly held up as a utopian ideal achieved through advances in STEM, it also explores narrative arcs involving clashing ideals, battles, and war. Klingon society provides a strong foil to that of the Federation, as their primary purpose for STEM is not knowledge and exploration but conquering and war. The Mirror Universe, introduced through a glitch in the fantastical transporter technology, is a direct reflection of the *Star Trek* 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 the Collective is introduced in the same series as Data 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 has shown 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 human history, perhaps imagining or relating to a world in which meeting

new civilisations or trading for newly discovered resources is peaceful was not considered interesting television, thus necessitating the convergence of science exploration with war. *Star Trek* 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 Mirror Universe is initially reached in *TOS* as a result of a glitch in transporter technology, 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. With each manifestation of the Mirror Universe (*TOS*, *DS9*, *ENT*, *DSC*), the storyworld and its characters are antithetical 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. Major historical events, such as First Contact with Vulcans, are intact, yet 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 the 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 (see Ch 57). As Juli L. Gittinger notes “the Borg may have proceeded Web 1.0... but their posthumanism has certainly realized these anxieties and critiques of our technological selves” (2019, 66). 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 biotechnology 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 *Star Trek* 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 the 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 *Star Trek* science and technology that is often overlooked in favour of whizzy gadgets and engineering: body modification. The *Star Trek* 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' (6.20) 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 (transferral of viable organisms between planets seeding similar species), *Star Trek* 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), as discussed more thoroughly in Chapter 53. 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 *Star Trek*) male roles and also as aliens: Torres is human-Klingon 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. 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 they 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*, *PIC*), Seven of Nine (*VOY*, *PIC*), Icheb Manu Intiraymi (*VOY*), Casey King (*PIC*), and Hugh (Jonathan Del Arco, *TNG*, *PIC*). Unlike the Trill, no one joins the Borg by choice; it is a process that renders the individual mind/persona effectively dead, as the body is assimilated into a groupthink neural network.

The Borg reflect fears about the literal and virtual integration of technology with the self. When *TNG* aired, “digitization and miniaturization were in full swing” (Ballard 2015) 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). *Star Trek* 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 *DSC*. As Nicola Liberati (2018, 45) 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 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 (2018, 46).

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

Gene Roddenberry argued that “science fiction [was a] thing of the past” because *Star Trek* was “real adventure in tomorrow’s space” (1966: np). *TOS* 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 monsters and mad scientists (Allgaier 2018, 85). Although the series was created at the cusp of and into a dystopian SF 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 science organisations, such as RAND and NASA (Bormanis 2014), gave the show a legitimacy and also a reciprocal relationship with those key institutions that recognised the power of popular science communicated and diversified through fictional but widely accessible media.

Star Trek 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. *Star Trek* 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 *Star Trek* universe in its development over nearly 60 years has seen the inclusion of black ops and the dystopic Mirror Universe, it does so to encourage audiences to imagine STEM's viable "transformative possibilities" (Moynan 2007, 213). Science is power, science is political, but it does not always have to be imagined as inevitably apocalyptic.

References

- Allgaier, Joachim. 2018. “‘Ready To Beam Up’: *Star Trek* and its Interactions with Science, Research and Technology.” In *Set Phasers to Teach!: Star Trek in Research and Teaching*, edited by Stefan Rabitsch, Martin Gabriel, Wilfried Elmenreich, John N.A. Brown, 83-94. Cham: Springer.
- Ballard, Brian. 2015. “Tracing the Roots of Wearable Technology.” *Tech Crunch*. 24 November, <https://techcrunch.com/2015/11/24/tracing-the-roots-of-wearable-technology/>
- Bormanis, Andre. 2014. “Science Fictions and Fictional Science.” In *Hollywood Chemistry: When Science Met Entertainment*, edited by Sidney Perkowitz, Donna J. Nelson, Kevin R. Grazier, Jaime Paglia, 17-24. Washington DC: American Chemical Society.
- Blaxter, Mark and Kazuharu Arakawa. 2017. “Tardigrades in Space.” *The Biologist* 64 no. 1: 14-17.
- Buzan, Barry. 2010. “America in Space: The International Relations of *Star Trek* and *Battlestar Galactica*.” *Millennium* 39 no. 1: 175-180.
- Chambers, Amy C. 2020. “*Star Trek* Discovers Women: Gender, Race, Science, and Michael Burnham.” In *Fighting for the Future: Essays on Star Trek: Discovery*, edited by Sabrina Mittermeier and Mareike Spsychala, 267-286. Liverpool: Liverpool University Press.
- Chambers, Amy C. and Lisa Garforth. 2020. “Reading Science: SF and the Uses of Literature.” In *The Palgrave Handbook of Twentieth and Twenty-First Century Literature and Science*, edited by The Triangle Collective, 243-261. New York: Palgrave.

- Csicsery-Ronay, Istvan 2008. *The Seven Beauties of Science Fiction*. Middletown: Wesleyan University Press.
- Cranny-Francis, Anne. 1998. "The 'Science' of Science Fiction: A Sociocultural Analysis." In *Reading Science: Critical and Functional Perspectives on Discourses of Science*, edited by J.R. Martin, and Robert Veel, 63-80. London: Routledge.
- Friedensen, Rachel E., Ezekiel Kimbal, Annemarie Vaccaro, Ryan A. Miller, and Rachael Forester. 2021. "Queer Science: Temporality and Futurity for Queer Students in STEM." *Time & Society* 30 no. 3: 332-354.
- Gittinger, Juli L. 2019. *Personhood in Science Fiction*. Cham: Palgrave Macmillan.
- Grech, Victor. 2020. "Doctors in *Star Trek*: Reflections on the changing faces of future doctors." *Early Human Development* 144: 1-3.
- Kirby, David A. and Amy C. Chambers. 2018. "Playing God: Religious Influences on the Depictions of Science in Mainstream Movies." In *Science, Politics and the Dilemmas of Openness: Here be Monsters*, edited by Brigitte Nerlich, Sarah Hartley, Sujatha Raman, and Alexander Smith, 278-302. Manchester: Manchester University Press.
- Kirby, David A. 2003. "Scientists on the Set: Science Consultants and the Communication of Science in Visual Fiction." *Public Understanding of Science* 12, no. 3: 261-278.
- Liberati, Nicola. 2020. "The Borg-eye and the We-I: The Production of a Collective Living Body Through Wearable Computers." *AI & Society* 35: 39-49.
- Moylan, Tom. 2007. "Realizing Better Futures, Strong Thought for Hard Times." In *Utopia Method Vision: The Use Value of Social Dreaming*, edited by Tom Moylan and Raffaella Baccolini, 191-222. Oxford: Peter Lang.

- Naples, Nancy A. and Barbara Gurr. 2014. "Feminist empiricism and standpoint theory: Approaches to understanding the social world." In *Feminist Research Practice*, edited by Sharlene Nagy Hesse-Biber, 14-41. London: Sage.
- NASA Science. 2021. "Space Experiments: Cell Science-04 (CS-04)." *NASA Science*. ND. <https://science.nasa.gov/biological-physical/investigations/cell-science-04>
- Prescod-Weinstein, Chanda. 2021. *The Disordered Cosmos: A Journey into Dark Matter, Space Time, & Dreams Deferred*. New York: Bold Type Books.
- Roberts, Robin. 2000. "The Woman Scientist in *Star Trek: Voyager*." In *Future Females, The Next Generation: New Voices and Velocities in Feminist Science Fiction Criticism*, edited by Marleen Barr, 277-290. Lanham: Rowman & Littlefield Publishers.
- Roddenberry, Gene. 2018 [15 November, 1966]. "Science fiction thing of past." *The Hollywood Reporter*, 4 September <https://www.hollywoodreporter.com/news/general-news/gene-roddenberry-explained-star-trek-1966-1092983/>
- Saltzberg, Steven. 2017. "New *Star Trek* Series Makes Massive Science Blunder." *Forbes*, 30 October. <https://www.forbes.com/sites/stevensaltzberg/2017/10/30/new-star-trek-series- makes-massive-science-blunder/#11ce2591b377>
- Song, Lin and Chris K.K. Tan. 2020. "The Final Frontier: Imagining Queer Futurity in *Star Trek*." *Continuum* 34, no. 4: 577-589.
- Snow, C.P. 1998 [1959]. *The Two Cultures*. Cambridge: Cambridge University Press.
- Weldes, Jutta. 1999. "Going Cultural: *Star Trek*, State Action, and Popular Culture." *Millennium* 28: 117-134.

van Dijck, José. 2003. "After the "Two Cultures" Toward a "(Multi)cultural" Practice of Science Communication." *Science Communication* 25, no. 2: 177-190.

Vint, Sherryl. 2014. *Science Fiction: A Guide for the Perplexed*. London: Bloomsbury.