Preface

As man reaches into space, he will acquire new drugs, food, minerals, and knowledge which he cannot conceive of now.

—Gene Roddenberry, *The Making of Star Trek*, p. 200

Two popular genres in American television of the 1960s were science fiction and westerns. The most popular science fiction show was probably *The Twilight Zone*, which ran from 1959 to 1964, but live action and animated programs were both popular throughout the decade. While *The Outer Limits*, *The Jetsons*, *Lost in Space*, *Jonny Quest*, *Thunderbirds*, and *Voyage to the Bottom of the Sea* all had short runs in the 1960s, one should not forget the most successful of all the science fiction/fantasy of that time, *Doctor Who*, which originally ran from 1963 to 1989 on the BBC. Into this landscape of space- and cattle ranching-based story visual telling came *Star Trek* in 1966.

Series creator Gene Roddenberry intended *Star Trek* to be a "Wagon Train in the cosmos," a wild-west show with starships. Gene was also a fan of technology, so science soon came to the forefront in his new fiction series. Flight in deep space and between planets was a staple of *Star Trek*, with the starship *USS Enterprise* as a critical character in the show. This was a direct result of Roddenberry's experiences in the air. Gene originally studied law enforcement at Los Angeles City College, switching to aeronautical engineering just before the USA entered World War II.

Roddenberry earned his pilot's license in 1941 and shortly thereafter volunteered for the US Air Corps. He flew 89 combat missions, earned the Distinguished Flying Cross the Air Force Medal during the war, and was shot down twice. While stationed in the South Pacific, he submitted stories and poetry for publication with considerable success. After the war ended, Gene flew as a commercial pilot for Pan-Am World Airways, running the longest routes they had. He retired soon after a 1947 crash in Africa that claimed the lives of several passengers. It was then that he decided to pursue writing for the new medium of television, returning to Los Angeles with his new found love for engineering and flight.

Six television series (five live action and one animated), thirteen movies, and 50 years later, we are now ready to celebrate the golden anniversary of the original Star Trek challenge to, "Go where no man has gone before." The stories, characters and technology are as popular as ever, and because of this, the franchise continues to grow. The latest J.J. Abrams produced film debuted this summer (2016), and a new series that links to the original television show is in production, scheduled to debut in 2017. While both Doctor Who and Star Trek have thrived over the years, the two series differ in their approaches to technology. Doctor Who is closer to the fantasy end of the spectrum, focusing more on interpersonal stories rather than technology, although there will certainly be those fans who would argue the point. Star Trek is known for its social commentary, yet it is the technology and the science behind the high tech toys (implied, casual or plausible) that separates Star Trek from Doctor Who and many other science fiction shows.

One can point to any number of toys and tools that *Star Trek* either introduced or more thoroughly explained. In many cases, the explanations were cursory or developed only over time, and several were convoluted combinations of jargon and science concepts. Regardless, it has been shown over the decades that *Star Trek* made sense, both as storytelling and science. Roddenberry hired Harvey P. Lynn of the Rand Corporation as a part-time consultant to vet the science before the original series debuted. He made suggestions as to terminology to use on the show and let Roddenberry know when the writers' vision did not match the known science of the day. The subsequent production teams continued relying on consultants to ensure that the science and technology were at least plausible, and the writers had technical guides to make sure that there was consistency in the gadgets and the explanations of their function.

The universal translator allowed species that had never met before to converse without subtitles, although the communication itself sometimes became the story. Other technologies were meant to save the crew from mundane tasks of day-to-day survival. Being able to replicate food eliminated the need for growing crops and raising animals, or for interrupting a five-year mission to restock bullion cubes and hot pockets every few months. The tricorder began as a mechanism to provide a certain female yeoman an excuse for being on screen more often, according to SE Whitfields's and Roddenberry's book, *The Making of Star Trek* (p. 169). But the majority of the technological equipment served to highlight the humanity of the characters (Scotty's babying of the dilithium crystals to keep the ship going, Geordi's visor, Data, and the Borg) or help the stories to be exciting and cutting edge (transporters, phasers, deflectors, cloaking devices, and replicator). In the production sense, some technologies provide information to the viewer or save time in order to move the plot along (tricorder, universal translator, communicator, and transporter).

Since *Star Trek* aired for only three seasons in its first run, most people fell in love with the USS Enterprise via syndicated reruns. New episodes were not produced again until 1987, so a whole generation of viewers (1969–1987) grew up with only the 79 episodes. Despite this limitation, fifty years of science training has been influenced by the hard technology of this series. In speaking to dozens of researchers for this book, almost all were familiar with *Star Trek* and most indicated

that the series had an effect on either their desire to study science or on their research track. Dr. Asier Mazo, of Pamplano, Spain, told me that his group definitely had *Star Trek* in mind when they built and named their holographic acoustic tractor beam, and Dr. Tracy Canfield does not just study computational linguistics, but she is also an expert in Klingon and a science fiction author in her own right. *Star Trek* has transcended the small and big screens; research laboratories around the world are turning Trek science fiction technologies into science fact.

Many of the franchise's technologies existed in literature before Roddenberry starting contemplating scattering McCoy's atoms across the universe. Tractor beams were first described as attractors or repulsors in several Buck Rogers and other short stories of the late 1920s and early 1930s, but *Star Trek* gave us the graviton as an explanation of how they work. George Gamow described faster than light speed in a series of scientific fables in the 1880s, thirty years before Einstein told us it was not possible. Fortunately, creative writers ignored Einstein's speed limit and have invented many mechanisms for moving astronauts beyond the speed of light. *Star Trek* introduced warp drive and plasma subspace bubbles, once again providing a more scientific framework for a previously described fictional technology. Most famously, Isaac Asmiov introduced R. Daneel Olivaw and his positronic brain in the Robot series of 1940. The explanation for the workings of Daneel's brain was sorely lacking; Asimov said only that it was constructed of a platinum/iridium alloy. Rodenberry and his successors provided a bit more of the mechanism behind Mr. Data's positronic neural net, and seeing the lights and connections during his maintenance gave it a computer-like appearance, mimicking human synaptic activity.

Other technologies from *Star Trek* were explained in much more detail and have been shown to have parallels in our world. This book describes several fictional devices that have a distinct possibility of being realized in the next decades as well as the research that is bringing those functions to life. In some cases, the tools of *Star Trek* are mimicked outright, trying to achieve the same exact function in an engineered fashion. In other cases, the technologies being developed now are a stylized or scaled version of those seen in the series and movies. Some of the most amazing stories play out when the fictional mechanisms of action for *Star Trek* devices become science fact, in either direct fashion, as with many of the wireless sensor technologies of the tricorder, or in the spirit of the *Star Trek* tool. For example, Chap. 1 discusses optical phased arrays, which are a way to control laser beams; this is connected to the phaser because *Star Trek* described it as a "phased array emitter" decades ago. Amazingly, new research suggests that optical phased arrays are going to be important in developing directed energy weapons like the phaser.

In 2002, science and science fiction author Gregory Benford wrote in *The Magazine of Fantasy and Science Fiction* about the use of "wuantum mechanics" in some science fiction stories (103(4–5); 187, 2002). Used as a writing and plot crutch, a wuantum mechanics device is any piece of technology never spoken of before, but which some character pulls out of nowhere in order to survive the impending catastrophe and save the day. Or perhaps a known piece of technology is

quickly modified using previously unknown terminology and mechanisms that have no basis in reality. True, Geordi and Picard sometimes made things all better when they "modified the main deflector to emit an inverse tachyon pulse" so they would, "be able to scan beyond the subspace barrier," (*TNG: All Good Things*) but examples of quantum mechanics are less common in *Star Trek* than in other series or stories. The believability factor was a big part of Roddenberry's vision of *Star Trek* and was the reason he hired Harvey Lynn, the reason the writers had technical manuals, and the reason that many franchise technologies are coming true.

Star Trek was/is prophetic in so many areas, from communicators turning into mobile phones, to talking computers that we now call Siri. In many cases, the transition from science fiction to science fact has been so direct that devices and products hit the market with *Star Trek* names. There is a 3D printer called a replicator, a nonlethal laser weapon called a PHaSR, a ten million dollar design prize for making a tricorder, and the NASA design for a warp drive ship we currently cannot build is called the INX Enterprise. Commercials, websites, and the news media constantly compare emerging technologies to those things we have seen on *Star Trek*. Some comparisons are apt, while others are exaggerations intended only to increase sales or viewership. The descriptions and uses of technology by Kirk and others are so vivid that they have stuck in the public consciousness, so that modern research may quickly evoke memories from *Star Trek*. But perhaps more importantly, current science advances show how forward thinking and accurate many *Star Trek* technologies were. Roddenberry was not just a writer and producer; he was a futurist of the first order.

So if *Star Trek* predicted so many advances and was so accurate in its technology, why aren't we telling our replicator what we want for dinner, bouncing bullets off deflector shields, and hiding our dirty dinner dishes behind cloaking devices? In some cases, the reason is that the research has not yet reached a crucial point. Scientists have not isolated the graviton particle yet, so we cannot make a true *Star Trek* deflector or tractor beam. If and/or when the graviton is discovered, it might be decades before man could harness it to do work, if at all. For other technologies, the problem is a matter of scale. While today's lasers are powerful enough to imitate handheld phasers, laboratories are nowhere close to producing lasers that can disintegrate a building or planet. Some devices need to get bigger; current tractor beams can only move miniscule objects. Other things need to get smaller—the visual prostheses that are available today require outside peripherals, cameras, and lots of wires, while many particle accelerators cover 20 or more square miles—too big for a handheld weapon.

This book is divided into nine chapters, one for each selected technology. Each chapter describes how *Star Trek* used a device or technique and the science that the writers used to explain the workings of each one. With this information as a base, the remainder of the chapter surveys the state of the research that mimics or parallels the *Star Trek* version and the research that may allow for a true approximation or realization of the technology. In some cases, the research is a new twist on old engineering methods, such as how the magnetic field around Earth can be simulated to protect astronauts as a deflector shield or how gravity itself can be used to tractor

asteroids away from a collision course with Earth. In other cases, completely new engineering and physics has afforded science the opportunity to pursue *Star Trek* gadgets. Metamaterials, quantum dots, plasma toroids, retinal mapping, statistical machine learning—these have all contributed to the progress science has made toward *Star Trek* technological magic.

When episodes or movies are referenced to make a point about how a technology is used or how it functions, an effort has been made to identify the series and episode in which that canonical information can be found. The series will be abbreviated as follows: *Star Trek: The Original Series* will be abbreviated *TOS*; *Star Trek: The Next Generation* as *TNG*; *Star Trek: Deep Space Nine* as *DS9*; *Star Trek: Voyager* as *VOY*; and *Star Trek: Enterprise* as *ENT*. If the references are from a film, the entire title will be used. Other reference materials are used as well, and the technical manuals from several of the series help explain the technologies within the *Star Trek* universe.

The latest scientific research is used to explain how people are pursuing the technologies exploited in *Star Trek*. The pertinent papers, books, or websites and press releases are listed at the end of each chapter. The research is cutting edge, so some additional information explaining background or interesting related points is pointed out in text boxes in each chapter. Additionally, emerging technologies may appear in more than one chapter. These connections are highlighted, and the sections of other chapters are stated. For example, metamaterials research is applicable for the realization of cloaks, deflectors, and tractor beams, while lasers are important for phasers, replicators, tractor beams, and tricorders. Finally, the words of the researchers are used where ever possible to explain the concepts behind their work and in relating the influence of *Star Trek* on their work.

The book is not comprehensive by any means. Each chapter focuses on a single theme, while other topics are not described for reasons of space or due to the need of significant additional background. While each topic is explained so that a nonprofessional can follow the research, the text does include significant numbers of technical terms to help the reader seek additional information. Likewise, the list of *Star Trek* technologies discussed is not exhaustive. Most of the included technologies were chosen for their position in science right now. Communicators were omitted because society has gone beyond them by now with smartphones and bluetooth. PADDs are likewise commonplace now; millions of people use similar tablet computers every day.

Some technologies are not in the book because they have not gotten to the experimentation stage yet. Yes, warp drive has moved from NASA's conjecture stage to their reasoned speculation level, but humans only have experience with conventional rockets and a few new technologies that might allow us to go marginally faster. No current line of research can produce anything like warp drive or even a warp drive precursor. Twenty years ago, Mexican physicist Miguel Alcubierre did some mathematics that suggested that warp drive could be possible if someone can develop an energy/density field that is lower than that of a vacuum. What does that mean? Science needs to find a way to engineer a negative mass and something called negative energy. Since these new entities are nowhere in sight, the

technology will have to mature before a discussion of warp drive is appropriate in this type of forum.

Artificial intelligence (AI) is not given a chapter because the science is also too immature. Though Chap. 6 discusses statistical machine learning and neural nets in the context of artificial intelligence, this is not true AI by a long shot. Futurist Neil Gershenfeld is of the opinion that mankind will soon be able to merge brains and computers. Perhaps this will help us learn enough to mimic intelligence in an artificial network, but there is no data to suggest such a merging is yet possible. No matter how determined the media is to report that AI is either here or just around the corner, true machine learning without significant human input and sentience in a machine is probably half a century to a century away at best.

Holodecks are not included because they involve several future technologies that are all beyond present science. We do have some types of virtual reality that let you see additional objects or surround you with different scenery; there are even some that transmit sensations or movements in those realities and allow you to manipulate virtual objects. However, none of these technologies allow you to pick objects up like in a *Star Trek* holodeck or have it respond creatively if you go off program. The holodeck uses replicators, holograms, transporters, and AI, none of which we have yet. Therefore, it would be hard to intelligently discuss holodecks that use them all. Transporters and replicators do have their own chapters, so one can look at the progress science is making with them. Then, throw in a bit of optical phased arrays from the phaser weapon chapter to include holograms, and together, these will give one an idea of where holodeck research might be headed.

The legacy of *Star Trek* and the role it has played in driving research and researchers must be honored. *Star Trek* may be entertainment, but it is entertainment with a sociological and technological edge. The public needs to be aware of the amazing science that is behind the sci-fi technologies that entertain and amuse them. Even if some of this research would have been pursued had *Star Trek* never made it to television, there is no doubt the franchise has spurred research that has expanded knowledge and inspired people to enter the world of science. Even if much of the work being done in laboratories all over the world produces only personal tools that we recognize from the series, *Star Trek* is also important because it stimulates work that helps mankind to better explain his universe and his place in it. Science is truly going where no person has gone before, and *Star Trek* continues to play a role in that journey.

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http://www.springer.com/978-3-319-40912-2

The Realization of Star Trek Technologies
The Science, Not Fiction, Behind Brain Implants, Plasma Shields, Quantum Computing, and More
Lasbury, M.
2017, XXII, 320 p. 77 illus., 69 illus. in color., Softcover
ISBN: 978-3-319-40912-2