Science and science fiction have been passions of mine since childhood. But the combination of the two—using science fiction as a vehicle for teaching science—is something that I only began to explore in relatively recent years. We live in an increasingly technological world, in which it is increasingly important for people to be scientifically informed. But traditional courses in science at the college level are usually geared toward students who are already on their way toward careers related to science, technology, engineering, or mathematics—the so-called STEM fields. Although there are some notable exceptions, most of the offerings in science for students in the fine arts, humanities, and social sciences continue to be watered-down versions of courses intended for science or engineering students. Students who take such courses often do so simply to fulfill a degree requirement and with a sense of trepidation. They often complete such courses with no more interest in science than when they signed up. The present work has one primary goal: to make science accessible to a broad audience, including both nontechnical students and technically oriented students, with a view toward increasing public awareness of and interest in science.

Content and Scope

The content of the book is organized around seven major questions, which are frequently addressed in works of science fiction: What is the nature of space and time? What is the universe made of? Can a machine ever become conscious? Are we alone in the universe? What does it mean to be human? How do we solve our problems? What lies ahead? There is a deliberate progression in these seven major questions, beginning with the most objective (changing perspectives through history concerning the nature of space and time, the fundamental building blocks of matter, and the properties of materials), followed by topics which have both objective and subjective dimensions (Is consciousness computable? Is there intelligent life elsewhere in the universe? What, if anything, sets humans apart from other
closely related species?), and ending with questions that may be more controversial and speculative (How do we distinguish between science and pseudoscience? How is science used or misused in attempts to solve the problems facing society? What will the future hold for our technological society?). In addition to the major questions, each of the chapters includes suggestions for further exploration, with more specific questions and references to scientific literature.

Much of the emphasis in this book reflects my training as a physicist. Yet I do not subscribe to the narrow view of science held by Ernest Rutherford, a famous physicist of the early twentieth century, who proclaimed, “All of science is physics. The rest is stamp-collecting.” A few of my colleagues have an even more narrow view toward science than Rutherford and will tell you that you aren’t even doing physics unless you are doing their particular brand of physics. When it comes to a discussion of what is science, I am willing to embrace considerably more diversity. Yet there are limits. A serious discussion of what is science and what is not science is also included in this book. Not all forms of human inquiry are rightly included under the umbrella of science.

The Approach

Science fiction is used throughout this book as a springboard for discussing both the fundamental principles of science and cutting-edge science research. Short scenes from science fiction movies and television episodes are critiqued in light of our current understanding of science. Class discussion focuses on discerning the level of plausibility of the science depicted in each scene. To this end, four general categories are useful. A handful of examples from some of the best movies turn out to be solidly based on good science—the things that we see on the screen are actually known to happen, essentially as depicted or as described in the dialog. An example that falls into this first category is the relativistic time dilation described in the opening scene of the original (1967) version of the *Planet of the Apes*. A second category includes things which are possible in principle, but beyond our current technology. That is to say, it hasn’t happened yet, but there is nothing in the laws of science to forbid it from happening. An example is the sentient android, Commander Data, in the TV series *Star Trek: The Next Generation*. A third category is stuff that just can’t happen as shown. Much of science fiction may be lots of fun to watch, but is simply impossible, and we will explore the reasons why. An example of this is the extraordinarily rapid rate at which the air leaks out of an interplanetary space ship, after being punctured by a micrometeoroid, in the 2000 movie *Mission to Mars*. Using a reasonable set of assumptions, we will come up with an estimate of how long it would really take and conclude that the screenwriters simply wanted to heighten the sense of excitement and danger. A fourth category is one that is growing rapidly as our technology advances: things which were purely science fiction at the time that the movie or TV episode was produced, but are now part of reality or are expected to become part of reality in the very near future. When the movie *GATTACA* was produced in 1997, the Human
Genome Project had not yet been completed, and the concept of rapid DNA sequencing, as shown in the movie, was purely in the imagination of the writers. It took an enormous government-funded research project 13 years to complete the sequencing of the first human genome. Full-genome sequencing can now be done in about 1 day at a cost of about $1,000.

Plausibility Checks and Quantitative Estimations

Some of the sci-fi illustrations are conducive to doing what we might call a quantitative plausibility check. That is to say, by watching the movie scene we can gather enough information to do a rough calculation and then decide if what we see could actually happen or not. In the text I call these Estimation Problems. The objective in each case is not to obtain a specific answer, which is either right or wrong (the sort of problems encountered in most introductory physics textbooks). Instead, the idea is to come up with an estimate, by making a reasonable set of assumptions to supplement the information you can gather directly from the movie scene. For example, how much power would be required for a handheld weapon, such as a Star Trek phaser, to vaporize a human body? The answer that you get will depend on what assumptions you make about how long the vaporization process takes (from watching a relevant scene) and about what the human body is made of. The nontechnical student should not be intimidated by the frequent use of equations in some of the chapters. Where calculations can be done, example problems are worked out in the text, and additional problems are proposed for you to work out on your own. Solutions for these Estimation Problems are included in an appendix.

Movie, TV, and YouTube References

Collectively, the chapters include over 180 references to specific scenes in 130 different movies and television episodes, spanning over 100 years of cinematic history. In general, but with a few notable exceptions, I refrain from passing judgment on these works from an artistic perspective. Some of the very worst sci-fi movies ever made actually include some rather useful illustrations and are likely to promote very fruitful discussions in class. Each chapter includes a list of references to movie and TV scenes, in the order that they are cited in the text. The entire collection of movies and TV episodes cited in the text is also included alphabetically in appendices at the end of the book.

Most of the visual material is available on DVD and is referenced by scene number for ease in selecting the desired scene for a classroom presentation. A few of the scenes from the most recent TV series episodes had not yet been released on DVD at the time of publication or are not yet part of my personal DVD collection. These are cited by season number, episode number, and air date.
How to Use This Book

The book was created as the primary text for a one-semester undergraduate course on science and science fiction. But anyone with an interest in science and science fiction will enjoy reading it. The level of mathematical sophistication is that of high school algebra, with a small amount of trigonometry. The amount of material included in the book is actually more than can be covered in a single semester. This allows some freedom for the prospective instructor to pick and choose, according to the desired emphasis of the course.

The more casual reader may enjoy looking at a particular science topic to see what sci-fi references are used or may prefer to look up a particular movie or TV episode in the appendices to see what science concepts are included. Although the list of sci-fi references is extensive, it is not possible to include every work that was ever produced in a book of this scope. Nevertheless, I hope that there will be something for everyone.

Acknowledgments

The story of the origin of this book is a case study in the orchestration of events. I owe a debt of gratitude to the many individuals and groups of individuals, who have played a role in this orchestration, either knowingly or unawares.

The first of these events happened before I was born, on the campus of what was then known as the Carnegie Institute of Technology. My father enlisted in the army during the Second World War and was stationed at Carnegie Tech, in the Army Specialized Training Program. My mother was working at her first job right out of high school, in one of the administrative offices on campus. Neither of them ever imagined when they first met that they would eventually marry and have a son, who would grow up to become a member of the faculty in the physics department, on that same campus, now called Carnegie Mellon University. It is fitting that I should acknowledge my parents. Obviously, without them I would not be here. I am grateful to them for providing the kind of environment in which someone interested in the sciences could thrive and for allowing me the freedom to choose my own path.

The earliest direct influence for the book can be traced back to an event in my seventh grade history class. The teacher, Mr. Joseph Karlik, was also the science and math teacher for seventh and eighth grade at our very small elementary school. He gave us a most unusual assignment for homework one day, which I seem to recall having to persuade my parents to allow me to complete. We had to watch an episode of the new TV series Star Trek, called The City on the Edge of Forever, which would air that evening. The episode imagines the possibility of time travel into the past (to Earth in 1930) and the changing of one small event (preventing a traffic accident), which results in all of history unfolding differently (delaying the
entry of the USA into the war and allowing Nazi Germany to develop the A-bomb first). The discussion in our next history class focused on how things today might be very different if a significant event of the past never occurred. Although my interest in science fiction had already begun several years earlier, with the cartoon series *The Jetsons*, my real love of science fiction began with this homework assignment. I was intrigued by the possibility of traveling through space and time, and the *Star Trek* character Mr. Spock became one of my role models. My other childhood role model was the famous marine biologist Jacques Cousteau. His underwater documentaries, produced by National Geographic, were something that I never missed on TV. Through most of high school I dreamed of becoming a marine biologist and sailing around the world on the *Calypso* to seek out and study new life forms in the Earth’s oceans. I went to college intending to major in biochemistry, which (I hoped) would lead to graduate school in marine biology. But a C in honors college chemistry prompted me to reconsider whether that was the best path for me to pursue. As I pondered what direction I should take, I recalled my high school physics class, and Mr. David Speer, who was without a doubt the best teacher I ever had in high school. I credit him, and the very positive experience I had in his classroom and laboratory, with the decision to change my major from biochemistry to physics. Thus began a long and complex path, which would eventually lead me to the physics department at Carnegie Mellon University.

Although he sometimes questions my sanity for doing things in nontraditional ways, I owe a very big debt of gratitude to Steve Garoff, my PhD thesis advisor and one of my closest colleagues in the physics department. Steve and I began our association in his second semester as a faculty member at Carnegie Mellon, when he was assigned to teach our advanced undergraduate laboratory course. I had already been working in the department for some years as a lecturer, primarily for our introductory lab courses, but had also been assisting regularly with our advanced lab course. Toward the end of the semester, Steve was lamenting to another colleague that he had lots of startup funds, but only one graduate student. I told him that by coincidence, I had been kicking around the idea of finally growing up and pursuing a PhD, and his research was very much of interest to me. The words had hardly left my mouth when Steve invited me to join his research group. My future would certainly have unfolded very differently, if Steve had not provided the opportunity to work with him—a decision, which I’m sure neither of us has ever regretted.

The basic framework for the book began to develop after the convergence of three events in the second half of the 1990s. The first of these events happened late in 1995, thanks to Janet, my one and only wife of more than 30 years now. At the time, she was working at Pinocchio Bookstore for Children, one of the last of a dying breed of independently owned bookstores in Pittsburgh. In this position she had easy access to information about all the latest books for grown-ups, as well as for children. Knowing my love of science fiction, in general, and of *Star Trek* in particular, she surprised me one day with a hardcover copy of *The Physics of Star Trek*, by Lawrence Krauss, which had just been published that year. Delightful to read, this brilliant work holds a permanent place on my list of all-time favorite books.
The second event in this trilogy came in November of 1996, when Lawrence Krauss, author of *The Physics of Star Trek*, visited Carnegie Mellon University to give a lecture, complete with video clips from some of his favorite *Star Trek* episodes. As I sat in the audience, enthralled by his presentation, I started to think that something like this would make a great course. Following the presentation, I managed to get Krauss to sign my first edition copy of his book, but wondered when I would ever have the time or opportunity to follow through on developing a course on the topic.

Two years later, in the fall of 1998, the opportunity presented itself. Susan Henry, then dean of the Mellon College of Science at Carnegie Mellon (1991–2000), called upon the faculty to create minicourses, whose primary purpose would be to keep first-year students interested in science. I proposed a course which would use science fiction as a springboard for discussing cutting-edge science research. Although I am a physicist, and my idea for the course was inspired by Lawrence Krauss and *The Physics of Star Trek*, there is much more to science than just physics, and science fiction encompasses much more than just *Star Trek*. I planned a 6-week minicourse around five major topics: the nature of space and time, properties of solid-state materials, robotics and artificial intelligence, the search for extraterrestrial intelligence, and the future of our technological society. Students would watch clips from a broad range of science fiction movies, spanning a century of cinematic history, as well as selected sci-fi television episodes, and critique the science content of the clips in light of our current knowledge. Class discussions would focus on assigned readings from current science literature. The proposal was received with great enthusiasm, and I’ve been offering the course once or twice every year since the spring of 1999. Special thanks are due to Walter Pilant, whose vast personal collection of episodes of *Star Trek* (both the original series and *The Next Generation*) provided many hours of useful background research and preparation for the course. Thanks also to Jeffrey Hinkelman, my dear friend and manager of Carnegie Mellon’s video collection, for his invaluable advice on the use of video materials in class, for correcting my mistaken understanding of gender stereotypes in sci-fi movies of the 1950s, and for acquiring many of the titles that I use in the course for the library’s permanent collection.

Serious work on the actual material for the book started with a second convergence of events, which began 10 years after the creation of the minicourse. The global economic crisis of 2009 resulted in the termination of a summer enrichment program in the sciences for talented high school students, of which I had served as the director for the previous 8 years. Official word of the termination came in March of 2009, leaving me in need of a creative outlet for the summer. I made a proposal to Gregg Franklin, newly appointed head of the physics department (2009–2013), to expand my popular minicourse on science and science fiction to a full semester course. Unlike the minicourse, which was restricted to first-year students majoring in the sciences, this course would be open to anyone on campus, regardless of their major or year. The primary goal of the course would be to make science accessible to students in the fine arts and humanities, while keeping enough rigorous content to hold the interest of the more technically oriented students in science or engineering.
This proposal was met with enthusiasm, not only by Gregg, but also by Kunal Ghosh, assistant head for undergraduate affairs in the physics department. Kunal has always been one of my biggest cheerleaders, and for years had been encouraging me to expand the course and offer it to a broader audience. The timing couldn’t have been more perfect to do just that. The announcement of the new course offering was made on campus just a few weeks before the May 2009 release of the new Star Trek movie, directed by J.J. Abrams. The university was quick to pick up on the connections, the most important of which was Zachary Quinto, a graduate of Carnegie Mellon’s School of Drama (class of 1999), who was very well cast as the new Mr. Spock. I was honored to be interviewed by the university, for a YouTube video promoting the expanded version of the course, which was uploaded in June 2009. A story about the course was also featured on the university’s homepage. I’d like to thank Jocelyn Duffy and Carrie Chisholm for their work in promoting the course to the university community and to the outside world.

For three summers in a row (2009–2011) I offered the full-semester version of the course to an increasingly diverse audience and gradually refined the content. Many thanks to the students who took this early version of the course, as it flew under the radar, so to speak, and as we worked out what requirements it would fulfill for the university’s various degree programs.

In April of 2011 I received an email out of the blue from Jace Harker, a publishing editor with Springer-Verlag, who was coming on a short visit to Pittsburgh. He asked if he could meet with me to discuss my work in undergraduate education in physics and to solicit ideas for new textbooks. Coincidentally, at my wife’s suggestion, I had already been toying with the idea of writing my own book for the science and science fiction course. Jace was very enthusiastic about the possibility of publishing my lecture notes. But at that time they existed only in my head and in the form of a six-page spreadsheet of all the film references that I use day by day in the course. At his request, I created a detailed chapter outline, which he circulated for peer review at Springer. By the end of September he sent me a draft of a contract to write the book. Thanks to my good friend Steve Paschall, who kindly offered to review the contract from an attorney’s perspective. He raised several insightful questions, all of which were addressed to our satisfaction. The final contract was officially signed in October 2011.

Countless hours over the next 14 months were devoted to putting the ideas from my head onto the printed page and doing the research to locate the important science references that I felt were needed to make a proper textbook. I owe a huge debt of gratitude to my wife, Janet, for her patience in watching lots of good (and not-so-good) science fiction with me and for her valuable suggestions of material to include in the book. I’d like to extend a word of thanks to the Powe family—Janet’s sister Treva, brother-in-law, Joe, and our niece, Cati—with whom we spent our 2012 Christmas vacation in Texas, for their patience as I spent hours at their dining room table, typing away on the first draft of the manuscript. Thanks also to the Quick family—Donnalynne, Janet’s good friend from college, and her son, Austin (our godson), and daughter, Eliana—with whom we spent part of our summer vacation. They, too, had to put up with me, as I worked on the second
draft in their home in California. The manuscript was delivered in nearly final form at the end of December 2012, with only three-and-a-half hours before the contract deadline. Many thanks to Mr. Ho Ying Fan at Springer for reading the manuscript and making helpful suggestions for revision, as well as for shepherding the manuscript through the editing and publication process.

Finally, I’d like to thank three groups of individuals, whose prayers and encouragement have sustained me through the entire journey: my Tuesday lunchtime discussion group, including David Anderson, Robin Capcara, John Dolan, Bob Griffiths, David Handron, John Ito, Christoph Mertz, and Gary Patterson; our Wednesday evening house group, consisting of Alan and Linda Komm, David, Debbie and Karis Kornfield, Meredith Dobson, Jerry Martin, and Casey McDonald; and our Sunday morning fellowship group, which regularly includes Karen and Randy Woods, Carla and Jeff Sivek, Pam and Lou D’Abruzzo, Art Burt, and Virginia Phillips.

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