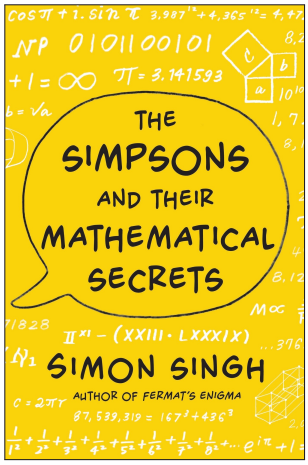

Animating Popular Mathematics: "The Simpsons and Their Mathematical Secrets"

Reviewed by Christopher Goff

The Simpsons and Their Mathematical Secrets
Simon Singh
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Your nonmathematical friends may have asked you about this book. Written by Simon Singh (who also wrote *Fermat's Enigma* [22]) and published by Bloomsbury (who also published the Harry Potter books), *The Simpsons and Their Mathematical Secrets* is wrapped in a bright yellow jacket and can probably be found in your nearest bookstore. Ostensibly about the mathematical references one can find in *The Simpsons*, the longest-running scripted show in television history [21], the book also covers *Futurama* [7] and the mathematical credentials of the two shows' writers. Through the lens of these programs, Singh glimpses the wider arena of mathematics and popular culture, describing several interesting ways in which the entertainment industry and the world of mathematics can interact.

The emerging field of mathematics and popular culture lies at the interface of these two seemingly disparate areas and examines how each can shape and be shaped by the other. As examples (though by no means an exhaustive list): mathematical models can be used to create special effects for animated and live-action films [1], [2], [18]; the ways in which characters with mathematical talent are portrayed (gender, race, age, and whether or not they are hyperintelligent) can affect audience attitudes towards mathematicians [16]; including popular culture references in the mathematics classroom can alleviate math anxiety and provide an access point to engage students in deep mathematical thinking [14]; new theorems can come from television shows [6]; and finally, the publishing market can support a popular work such as the book under review here.

The Simpsons was created by Matt Groening (of *Life in Hell* comic fame) as a set of vignettes for *The Tracey Ullman Show* on the Fox Network. Its success there led to a regular spot in the Fox lineup, where it has aired since the 1989–90 television season, garnering no fewer than ten Primetime Emmy Awards for Outstanding Animated Program. The Simpson family consists of nuclear plant safety technician Homer and his loving blue-haired wife, Marge; their troublemaking son, Bart; their academically talented daughter, Lisa; and their infant daughter, Maggie.

Still more success led Fox to ask Groening to create another animated show, resulting in the 1999 premiere of the science-fiction-themed *Futurama*, in which pizza delivery boy Fry accidentally falls into a cryogenic chamber on New Year's Eve 1999 and doesn't unfreeze until a thousand years later. In the future he befriends a robot named Bender and obtains a job as a delivery boy for a distant relative of his, the rather old and nerdy Professor Farnsworth. *Futurama* aired on Fox

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for four years, after which reruns were shown on the Cartoon Network for four more years. Underground popularity resurrected the show for four direct-to-video movies and an eventual return to series television on Comedy Central. The show won two Emmys for Outstanding Animated Program—one while at Fox and the other at Comedy Central—before coming to an end in 2013.

Both *The Simpsons* and *Futurama* are immensely popular, having been seen by millions of viewers. So, any mathematical references or jokes contained in their episodes are transmitted to many more people than a typical instructor of mathematics can ever hope to reach. As someone interested in the ways in which popular culture and mathematics interact, I am thrilled that a large publisher and a well-known author are shedding more light on some interesting examples of the interplay of mathematics and popular culture.

But the professional mathematical community is not Singh's target audience. Indeed, little in this book will be new to mathematicians who both observe and critique popular culture, especially those who are familiar with the work of scholars in this field. In particular, Dr. Sarah J. Greenwald and Dr. Andrew Nestler have been publishing specifically on *The Simpsons* and *Futurama* for over ten years and have created and maintained extensive websites [15], [19], [12]. I too have long been interested in this area, ever since I began giving conference presentations about mathematics and the movies in 2004. Shortly thereafter, Greenwald and I coedited a special issue of the journal *PRIMUS* [9] that focused on mathematics and popular culture. We have had another collaboration since then [4].

Singh interviewed Greenwald and Nestler for his book, and he quotes them throughout Chapter 8. He also includes an interesting anecdote about how the two mathematicians were implicitly responsible for adding mathematical content to an episode of *The Simpsons*. After Greenwald was interviewed for NPR's *Science Friday* in 2005, some of the writers heard the program. Intrigued that mathematicians were using material from the show in their classrooms, they invited Greenwald and Nestler to Fox Studios for a table-read, a key step in the process of writing any television script. After the mathematicians had left, however, the writers realized that the baseball-themed episode, titled "Marge and Homer Turn a Couple Play" (2006), contained no jokes of a mathematical nature. So they added three possible attendance numbers at a baseball game as a freeze-frame gag, that is, a joke that goes by so quickly that in order to see it fully, viewers have to record the show and pause the playback. Unbeknownst to most of the audience, the three numbers were a Mersenne prime (8191), a perfect number (8128), and a narcissistic number (8208).

Likely constrained by the fact that he was writing a popular book, Singh does not describe Greenwald and Nestler's (or others') prior contributions to the field in much detail, though he does mention them again in the acknowledgments and includes links to their definitive websites. For the academic audience of these *Notices*, however, I will continue to cite references in the area of mathematics and popular culture when they arise during the course of this review.

As do many mathematics books, *The Simpsons and Their Mathematical Secrets* begins with a Chapter Zero, in which Singh outlines some of the many ways that academia has interacted with the show. Professors of philosophy, psychology, and religion have written about how ideas in their disciplines arise in various plots and subplots revolving around the Simpson family. Even President George H. W. Bush famously criticized the Simpsons as antithetical to the wholesome all-American Waltons. The writers responded satirically (via Bart), "Hey, we're just like the Waltons. We're praying for an end to the Depression, too" [p. 2].

Singh rightly shines his spotlight on some of the writers themselves and their personal mathematical accomplishments. Since I also refer to these writers, I will list them by name: J. Stewart Burns (BS, mathematics, Harvard; MS, mathematics, Berkeley); David S. Cohen (BS, physics, Harvard; MS, computer science, Berkeley); Al Jean (BS, mathematics, Harvard); Ken Keeler (BS and PhD, applied mathematics, Harvard); and Jeff Westbrook (BS, physics, Harvard, and PhD, computer science, Princeton). Singh includes quotations in which some writers point out the similarities between mathematics and humor: Burns says that a mathematical puzzle and a joke share a common structure, and Cohen likens the task of telling a complex story in a short amount of time to solving a big logic puzzle. For more information about the writers, see [12], and for possible classroom uses of their interviews, see [11].

In Chapter 3, titled "Homer's Last Theorem," Singh mentions some connections between these writers and the story of Andrew Wiles's proof of Fermat's Last Theorem, the topic of Singh's 1997 book, *Fermat's Enigma* [22]. In particular, when Wiles spent a brief time at Harvard, Jean attended some of his lectures, and when Cohen was a graduate student at Berkeley, he attended some lectures of Ken Ribet. Singh mentions these connections while discussing a near-miss solution to Fermat's equation that appears as a background freeze-frame gag on Homer Simpson's chalkboard in the episode "The Wizard of Evergreen Terrace" (1998), namely, $3987^{12} + 4365^{12} = 4472^{12}$. Cohen

intentionally inserted this bit of mathematics as a prank, knowing that most calculators would, at first glance, not reveal its falsity, and he was thrilled to read the buzz that it generated online. As Cohen says in the book, "…when we get the opportunity to raise the level of discussion—particularly to glorify mathematics—it cancels out those days when I've been writing those bodily function jokes" [p. 37]. Interestingly, a couple of years after this near-miss example aired, Noam Elkies acknowledged it in a paper giving a new computational algorithm to obtain more general results [5].

Some might find it surprising that there are relatively close connections between the mathematics community and the entertainment industry. In Chapter 5, Singh introduces his audience to the Erdős number, which indicates how far removed someone is from Paul Erdős on the coauthor graph. Writer Westbrook has an Erdős number of 3, as does Cohen. A similar metric is playfully employed by fans of the movie business. An actor's "Bacon number" is her or his distance from Kevin Bacon on the costar graph, and Westbrook happens to have a Bacon number of 3. In the same way that one's Erdős number can be used as a proxy for one's connectedness to the mathematical community, so does one's Bacon number suggest prominence in Hollywood circles. Thus the tongue-in-cheek "Erdős-Bacon number" (i.e., the sum of the two numbers) can be used as a rough measure of someone's links to both Hollywood and the world of mathematics. As we have already seen, Westbrook's Erdős-Bacon number is 6. Surprising to me were the relatively low Erdős-Bacon numbers of the Hollywood stars Singh mentions in the book. Academy Award-winner Colin Firth's Erdős-Bacon number is 7, while Academy Award-winner Natalie Portman's is 6. Though not listed by Singh, Danica McKellar (from *The Wonder Years* and *The West Wing*) also has an Erdős-Bacon number of 6. Singh points out that Erdős himself has an Erdős-Bacon number of 4, but that this is not minimal. Apparently the lowest, 3, belongs to Bruce Reznick at the University of Illinois.

One more aspect about the writers that interested me was that they continued to study mathematics even while writing for television. In Chapter 9, Singh tells the story of how several writers formed a "math club" and took turns speaking to interested audiences or inviting others to speak, such as Ron Graham, and Greenwald and Nestler [13]. On an occasion when Cohen addressed the math club, he explained pancake numbers, the subject of a paper he wrote as an undergraduate [3]. I was amused by the story Cohen recounts in the book, that after a long journal lag time during which he began writing at Fox, his paper finally appeared in *Discrete Applied Mathematics*. He excitedly shared his good fortune with his colleague Keeler, who responded, "Oh yeah, I had a paper in that journal a couple of months ago." Keeler's paper [17] was even coauthored by Westbrook, another writer.

Interspersed between the stories of the writers and their mathematical credentials, Singh lists several instances of mathematics in *The Simpsons* and *Futurama* and explains them for a general audience. Many of these examples involve basic mathematics or statistics, and so I will focus on only a few that I believe are the most important in that they show interesting ways that mathematics and popular culture have the potential to interact. All of these are discussed in the book, starting with the 1990 joke that sparked Greenwald and Nestler's initial work and ending with the 2014 publication of the so-called "Futurama Theorem."

In Chapter 1, Singh describes the first official episode of *The Simpsons* to air, "Bart the Genius" (1990). In it, Bart writes his name on the completed aptitude test belonging to the class nerd, Martin Prince. Bart is thus "recognized" as gifted and placed into a different school, where the teacher writes $y = \frac{r^3}{3}$ on the board and says, "…if you determine the rate of change correctly, I think you will be pleasantly surprised." All the students except Bart solve the problem and begin to chuckle. The teacher works out the problem on the board and writes the answer $dy = r^2\ dr$ as "$r\ dr\ r$," saying, "har-de-har-har".

Unlike other examples, Singh avoids explaining the mathematics behind this one, other than a footnote reminding some readers how to differentiate r^n with respect to r. In a 2004 article [14], Greenwald and Nestler explain how they used this very scene as part of an assignment in a first-semester calculus course. They describe how it can help students review material before an exam and how it can even alleviate math anxiety in the classroom.

Greenwald and Nestler continue in the same paper to discuss the non-canon segment "Homer^3" (1995), in which Homer enters a futuristic three-dimensional world (as opposed to the presumably lower-dimensional nature of the Simpson universe) to escape an evening with his sisters-in-law. Classroom use of this vignette, an homage to a classic episode of *The Twilight Zone*, can spark a variety of interesting debates around two- and three-dimensional geometry and can initiate student thinking about the shape of four-dimensional space [14]. Singh devotes his Chapter 13 to "Homer^3," where he explains several of the freeze-frame jokes that the writers have inserted into the background, from statements like "P = NP" to Euler's equation, "$e^{\pi i} = -1$."

In addition to providing explanations of various mathematical tidbits, Singh also describes other ways that popular culture has the potential to comment on the mathematical community. The character Lisa Simpson, for example, is a bright young girl with obvious intellectual prowess in all disciplines, including science and mathematics. However, Lisa often experiences prejudice, either for being female or for being smart. The two come together in "Girls Just Want to Have Sums" (2006), which Singh focuses on in Chapter 7. This episode put the issue of women and mathematics front and center and treated it with the writers' usual satirical panache. In the episode, Principal Skinner makes tone-deaf comments about how girls are bad at mathematics (à la Larry Summers), prompting him to be replaced and the school to be split along gender lines. Frustrated by her new teacher's stereotypically "female" approach to mathematics instruction ("How do numbers make you feel?"), Lisa disguises herself as a boy, sneaks into the boys' class, and thrives so much that she ultimately receives the award for Outstanding Achievement in the Field of Mathematics. She unveils her true identity, proving that girls can do math too, at which point Bart claims that she succeeded only because she was acting like a boy.

This episode was the first to rely heavily on mathematics and its instruction as the main thematic material rather than as tangential references or freeze-frame gags. In the end, the writers explicitly side-stepped the question of why girls are underrepresented in mathematics by cutting Lisa off mid-sentence and replacing her with Martin Prince playing the flute. Singh goes on to describe similarities between Lisa Simpson and Sophie Germain (1776–1831), who had to use a male pseudonym to obtain Lagrange's lecture notes from the newly opened École Polytechnique. Greenwald also wrote about this episode, right before it aired. In an interview she and Nestler conducted with writer Westbrook in August 2005, he describes the then-upcoming episode and how the writers "didn't want to toe any ideologically obvious line either way" [10]. So while the writers did focus on the controversial debate about gender and mathematics, they tiptoed around it in the end.

Singh devotes the final four chapters to *Futurama*, also created by Matt Groening. David S. Cohen became head writer "David X. Cohen" (the name David S. Cohen having already been taken when television writers became unionized) and ramped up the quantity and quality of jokes involving mathematics, physics, and computer programming, such as the regular hexagonal cross-section of Madison Cube Garden and Bender's serial number of 1729. Singh describes these in detail, including the Ramanujan-Hardy story, and even explains Möbius strips and Klein bottles, which also show up on the *Futurama* screen. For more about these jokes and other examples of sums of cubes in the show, as well as possible classroom uses, see [8], [11].

In the last chapter, Singh describes something truly novel: the "Futurama Theorem." In the episode "The Prisoner of Benda" (2010), many of the characters use one of Professor Farnsworth's inventions, the Mind-switcher, to switch their brain into another character's body. Unfortunately, once the machine switches two minds, it will not work again on the same two. After several different exchanges, the characters wonder how they can get their minds back into their own bodies.

Keeler, while trying to complete the writing of the episode, cast the problem in the language of distinct transpositions and proved that in order to

guarantee a way to return everyone's mind back to her or his original body, at most two more individuals need to be included who have not previously swapped with anyone. In the episode, recurring characters "Sweet" Clyde Dixon and Ethan "Bubblegum" Tate (from the Globetrotter Homeworld and known for their mathematical, scientific, and basketball-playing talents) write Keeler's proof of the theorem on a glowing green blackboard and explain it to the professor, who is in Bender's body at the time.

Evans, Huang, and Nguyen [6] recently extended and optimized Keeler's original result, probably marking the first instance where a mathematical theorem created for a television show has entered the peer-reviewed world of academe. Mathematicians have long been inspired by problems that arise in other fields, but it seems surprising that a writing conundrum on a television show could lead to new mathematics. Perhaps mathematicians could benefit from the world of entertainment. In "The Prisoner of Benda," Keeler's proof was probably seen by 2.6 million viewers when it aired [23], while the paper by Evans et al. was likely seen by fewer than 16,000 [20]. Maybe those writers are on to something.

In sum, Singh writes engaging prose explaining interesting mathematics to a general audience. He also succeeds in continuing the conversation about many of the connections between the mathematical world and Hollywood, such as the pedagogical uses of *r dr r* and a 3-D Homer, raising public awareness of the issue of women in mathematics, and the creation and proof of the Futurama Theorem. These examples epitomize the exciting possibilities for interplay between mathematics and popular culture. Though *Futurama* was canceled (again) in 2013, we can only hope that *The Simpsons* and its writers (and Singh) will continue to provide the world with high-quality mathematical entertainment.

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