

The image of scientists in *The Big Bang Theory*

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The image of scientists in *The Big Bang Theory*

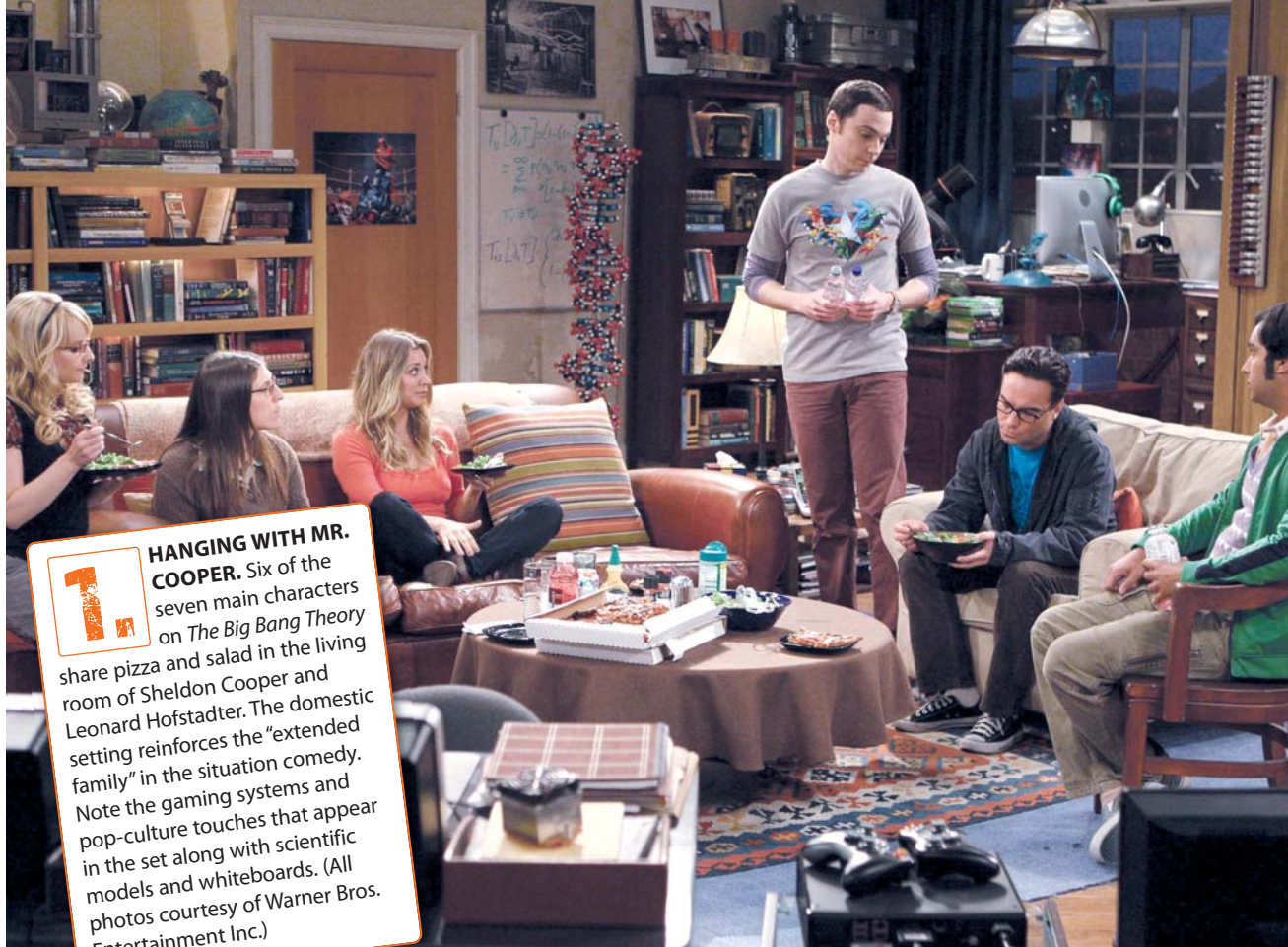
Margaret A. Weitekamp

In some ways, the hit TV show reinforces popular stereotypes about scientists. In others, notably in its affectionate portrayals, it plays against type.

Contemplating a heavy, oversized box that needed to be moved up several flights of stairs, the lead characters in the popular CBS television comedy *The Big Bang Theory* (2007–) established their primary identity as scientists. It was the show's second episode. Eager to impress the pretty woman across the hall, Leonard Hofstadter (portrayed by Johnny Galecki) appealed to his apartment mate, Sheldon Cooper (Jim Parsons), by calling on their shared vocation. "We're physicists. We are the intellectual descendants of Archimedes. Give me a fulcrum and a lever, and I can move the Earth," Leonard declared, just before he was almost crushed by the box. Broadcast in more than 25 countries, *The Big Bang Theory* has achieved worldwide commercial success. As Steven Paul Leiva opined in the *Los Angeles Times* in 2009, "*The Big Bang Theory* is the finest and best fictional portrayal of scientists in any current media—and a series that is carving out a place for itself in the annals of television comedy."







1. HANGING WITH MR. COOPER. Six of the seven main characters on *The Big Bang Theory* share pizza and salad in the living room of Sheldon Cooper and Leonard Hofstadter. The domestic setting reinforces the “extended family” in the situation comedy. Note the gaming systems and pop-culture touches that appear in the set along with scientific models and whiteboards. (All photos courtesy of Warner Bros. Entertainment Inc.)

In dramatic portrayals, particularly in films, scientists typically appear as stereotyped characters influenced by the long-standing figure of the “mad scientist” in literature, film, and television. And yet, one of the most successful comedies on television today features as its central characters a group of scientists, with several physicists among them. How should those characters be understood? *The Big Bang Theory*'s affectionate depictions of scientists have tapped into the contemporary popularity of nerd culture to create comedy grounded, especially in the early seasons, in authentic scientific content. Strikingly, when all the supporting players are accounted for, *The Big Bang Theory* portrays a group of scientists who are more diverse in gender, ethnicity, and especially disciplinary focus than is often seen on television. The characters and comedy of *The Big Bang Theory* both build on and play against enduring stereotypes of scientists as depicted in popular culture.

Ten seasons—and counting?

The CBS comedy created by Chuck Lorre, who also helped create *Two and a Half Men* (2003–15), and Bill Prady features as its two lead characters a pair of genius particle physicists who work at Caltech and share an apartment. The show found its audience during the summer of 2009 when CBS began airing reruns after *Two and a Half Men*, and its success grew from there. Seventy licensing partners produce branded merchandise related to the show. But the true extent of the show's worldwide popularity remains difficult to ascertain in this era of multiple television delivery systems—broadcast, subscription on-demand streaming services, even internet piracy.

The 10th season, which began last fall, continues the show's character-driven comedic formula. The show's central cast

comprises a locational “family” of young people—a group of single professionals and an aspiring actor—who gather in the lead characters' apartment, as shown in figure 1, or at Caltech. It echoes earlier television programs that expanded the traditional domestic-family-based situation comedy to include work families or families of roommates; those include *The Mary Tyler Moore Show* (1970–77), *Three's Company* (1977–84), *Friends* (1994–2004), and, more recently, *How I Met Your Mother* (2005–14). In *The Big Bang Theory*, the primary set—a somewhat nerdy living room shared by two bachelor roommates—reinforces the impression of a family in a domestic location.

In addition to Sheldon, a neurotic and rigid theoretical physicist, and Leonard, his long-suffering experimental-physicist roommate, the show centers on Penny (played by Kaley Cuoco), the attractive woman across the hall and Leonard's sometime girlfriend and later wife. From the beginning, the core triad was complemented by Rajesh Koothrappali (Kunal Nayyar), an astrophysicist who for several seasons could not talk to women unless he was drunk or medicated, and Howard Wolowitz (Simon Helberg), an engineer who drives a Mars rover, designs a space toilet, and even, in season 6, flies to the International Space Station (ISS). By season 4, two additional scientists had been established as main characters: Howard's girlfriend-then-wife, microbiologist Bernadette Rostenkowski (Melissa Rauch), and Amy Farrah Fowler (Mayim Bialik), a neuroscientist who dates Sheldon. Comic-book-store owner Stuart Bloom (Kevin Sussman), a recurring character in the show, appeared as early as season 2. Plot lines integrate some elements of the characters' occupations and hobbies throughout.

Fans, nonfans, and critics have disagreed about whether the portrayals of nerdy scientists in *The Big Bang Theory* offer an



2. BOYS' NIGHT OUT. Penny, dressed for a date, encounters “the guys”—from left to right, Leonard, Howard, Sheldon, and Raj—returning from a Renaissance fair in elaborate costumes. The juxtaposition of an outsider with the core group gives viewers who might be unfamiliar with costume play or the guys’ other hobbies a perspective from which to understand their activities.

overall negative or positive depiction. Some have argued that a comedy featuring such characters must amount to a kind of blackface in which the central characters serve as the butt of the jokes. But Lorre’s handwritten notes for a never-given Golden Globe speech, shown as an end card after one episode, point to a more complimentary interpretation: “show not about geeks or nerds, [but] about extraordinary people.” Moreover, the attention paid by the show’s producers, writers, and set dressers to scientific and nerd-culture accuracy suggests that the scientists be understood as quirky but lovable despite being isolated by their inside jokes and scientific knowledge. Such sympathetic portrayals stand in contrast to the well-established mad scientist archetype.

Stereotypes of scientists

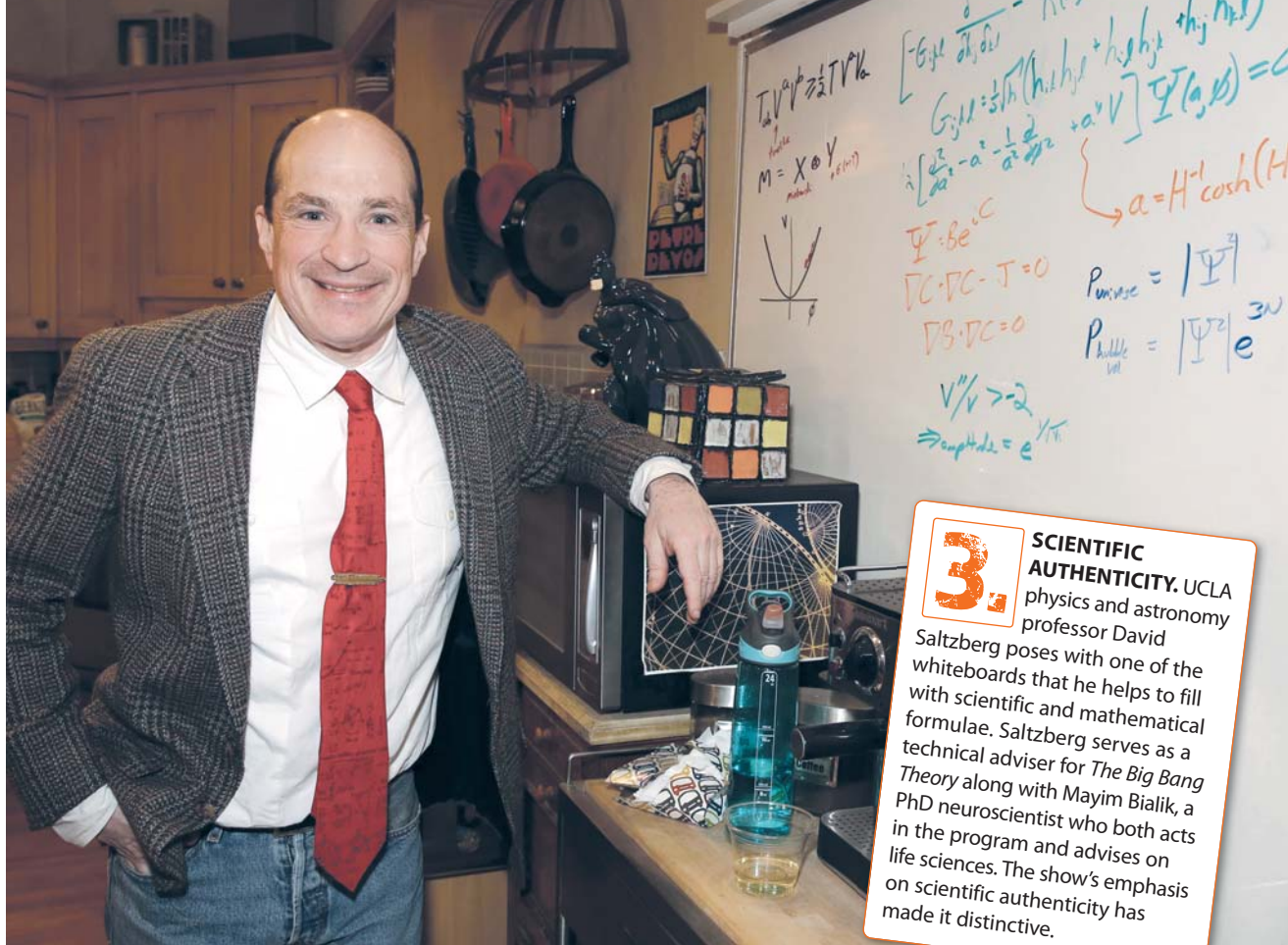
Rooted in a long-standing association of genius with insanity that found new life and new adherents in the early 19th century, the figure of the mad scientist has appeared frequently in literature and in science-fiction and horror films. Movies such as *A Beautiful Mind* (2001) and *Proof* (2005) celebrate genius mathematicians but also illustrate the purported relationship between mental illness and startling insight. Outsized intellectual development is often depicted as paired with some limiting condition. Two recent feature films juxtapose intellectual genius with either a crippling physical condition or contemporary social persecution. *The Theory of Everything* (2014) tells the story of astrophysicist Stephen Hawking’s intellectual development in the face of the debilitating motor neuron disease ALS (amyotrophic lateral sclerosis). And *The Imitation Game* (2014) depicted not only cryptologist Alan Turing’s vital contributions to British World War II code breaking but also

his tragic death in 1954, two years after he was convicted for homosexual acts.

Scholars have studied the appearance of scientists in mass media as a part of the broader scholarship on popular understanding of science. Researchers contributing to that larger effort have, for example, looked at how actual scientists communicate via mass media, how accurately news coverage depicts science and scientists, and how fictionalized visions of scientists affect perceptions of science.

When, in 2002, a group of Bruce Lewenstein’s graduate students at Cornell University analyzed the image of science in popular media, they found that “the scientist” had become a series of identifiable, linked stereotypes. There was the absent-minded professor, a socially isolated man—almost always a man—completely absorbed in his work. A variation was what the Cornell researchers called the mad scientist (think Dr. Frankenstein), a researcher whose obsessions were at best misguided or at worst actually evil. Many disaster or monster stories in film and television feature the scientist as a voice in the wilderness, a researcher whose expertise encompasses whatever disaster is unfolding but who fails to communicate the danger effectively—often because he is so socially removed. The scientist as passive pawn is controlled or co-opted by the military or big business. All those categorizations share a basic impotence: the stereotype that scientists, because of their dedication, fail to exercise their masculinity appropriately.

In addition, the hyper-rational observer—think Sherlock Holmes, *Star Trek* (1966–69) science officer Mr. Spock, or *Bones* (2005–) forensic anthropologist Temperance Brennan—is a scientist who is aloof or socially awkward but exhibits superior analytical skills. A final example is the unlikely hero, the



3. SCIENTIFIC AUTHENTICITY. UCLA physics and astronomy professor David Saltberg poses with one of the whiteboards that he helps to fill with scientific and mathematical formulae. Saltberg serves as a technical adviser for *The Big Bang Theory* along with Mayim Bialik, a PhD neuroscientist who both acts in the program and advises on life sciences. The show's emphasis on scientific authenticity has made it distinctive.

scientist who comes through with the solution in the end. Overall, scientists are more likely to be depicted in film than on television and more often in drama than in comedy. Although there exist dramatic depictions of women scientists, often as doctors or medical examiners, most popular-culture portrayals of scientists reinforce the idea that scientists are white and male.

Light-hearted depictions of scientists are not necessarily any less stereotypical. Some comedic depictions just play a stereotype for laughs, as in *The Absent-Minded Professor* (1961) and its remake *Flubber* (1997). On television, the handsome and affable “professor” spent three seasons marooned on *Gilligan’s Island* (1964–67) without much expanding the stereotype of the romantically oblivious scientist.

The scientists depicted in *The Big Bang Theory* build on another stereotype: the geek or nerd. The two terms are rooted etymologically in the first use of “nerd” in a Dr. Seuss book of 1950 and in the circus term “geek,” for the sideshow performer who bites the heads off chickens. The *Oxford English Dictionary* has defined a geek as one who is “foolish, offensive, or worthless.” The cultural stereotype depicts an awkward, outcast individual whose intense intellectual interests accompany general social discomfort. No clear distinction exists between the terms nerd and geek; I use them interchangeably.

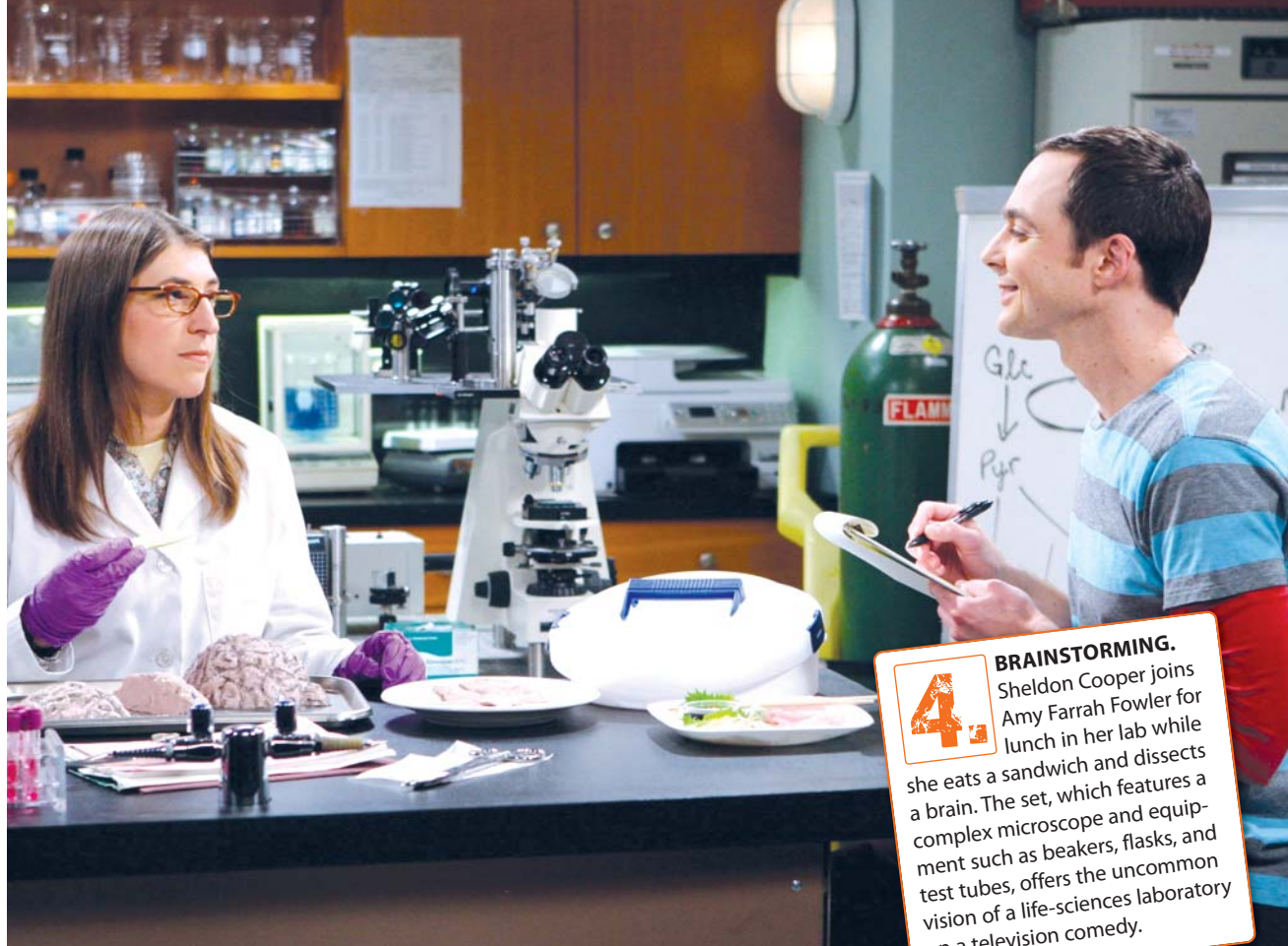
The widespread proliferation of personal computers in the 1960s and 1970s created a new kind of nerd: the computer geek. Beginning in the 1980s, however, the nerd stereotype shifted as the business of networked computers made millionaires and billionaires of many of its pioneers. After the late 1990s dot-com boom, geek became chic. The exploits of nerds-turned-tycoons and their would-be imitators have been valorized in

motion pictures such as *The Social Network* (2010) and television programs such as HBO’s *Silicon Valley* (2014–). *The Big Bang Theory* creator Prady knows geek culture, having worked briefly as a computer programmer. For *The Big Bang Theory*, nerds form both its subject and much of its audience. To appeal to the widest possible audience, however, Prady and Lorre created a character to help viewers understand the scientists.

Wendy to the Lost Boys

The Big Bang Theory offers a sympathetic portrayal of its core group of male scientists by making them underdogs: human, approachable, and vulnerable. But the first pilot that Lorre and Prady wrote for *The Big Bang Theory* defined the dynamic between the male scientists and the Penny character in a way that did not work. The female lead, initially named Katie (played by Amanda Walsh), was to have been a hardened, intimidating woman whose softer side would be gradually revealed by her interactions with the two male leads. Juxtaposed with the reclusive scientists, however, Katie seemed harsh, even mean. As Prady, reflecting on the initial pilot, reported to *Variety* in 2009, “What we didn’t anticipate . . . is how protective the audience would feel about our guys.” In the end, CBS did not pick up the pilot.

In the first draft of the revised pilot, the newly envisioned Penny character is still a hard-drinking party girl. In that version, when Sheldon and Leonard first notice Penny through her open apartment door, she is burning a photograph of an ex-boyfriend. When asked about the meaning of the gesture, she answers jarringly, “My desire to set him on fire.” When invited into Sheldon and Leonard’s apartment, Penny describes herself as “a José Cuervo shot girl, but I’m also writing a screenplay



4. BRAINSTORMING. Sheldon Cooper joins Amy Farrah Fowler for lunch in her lab while she eats a sandwich and dissects a brain. The set, which features a complex microscope and equipment such as beakers, flasks, and test tubes, offers the uncommon vision of a life-sciences laboratory on a television comedy.

about a girl who came to L.A. to be an actress and failed and wound up as a José Cuervo shot girl.”

The script’s final imagining created the popular central dynamic. Lorre and Prady recast the Penny character as an earnest, practical, Midwestern girl who becomes one of the guys. The contrast can be heard in the pilot that aired on 24 September 2007. Penny explains that although she is a waitress at the Cheesecake Factory, “I’m also writing a screenplay. It’s about this sensitive girl who comes to L.A. from Lincoln, Nebraska, to be an actress, and winds up a waitress at the Cheesecake Factory.” The punch line is that the screenplay is not about her; she’s from Omaha. Recasting Penny as sweet and Midwestern also allowed Lorre and Prady to reimagine the scientists as being vulnerable without being threatened. Cuoco has described her character as Wendy to the Lost Boys, in analogy to the famous character from J. M. Barrie’s *Peter Pan*. Moreover, Penny serves as a foil for the genius scientists, a reassuring outsider who gives viewers an entry point into scenes that are laden with unfamiliar technical or fanboy jargon.

The Sheldon character plays on the stereotype of the narrowly focused, socially inept, and physically awkward scientist. Interpreted by some viewers as having Asperger’s syndrome and by others as simply rigid, Sheldon lives a regimented life, attempting to impose rationality on the inherent unpredictability of ordinary social situations by requiring formal written agreements to govern relationships, whether with roommates or his girlfriend. He does not grasp sarcasm. And yet, the character rejects any accusation of madness, stating more than once, “I’m not crazy; my mother had me tested!” And he has friends. As a foursome, Sheldon, Leonard, Raj, and Howard adhere to a busy and, thanks to Sheldon, rather rigid

weekly schedule of game playing, comic-book collecting, science-fiction television watching, and movie viewing—all fueled by a steady diet of takeout and restaurant meals.

The Big Bang Theory conflates science knowledge with passionate fandom, two parts of the American nerd stereotype. It does so without questioning their relationship, and in doing so, it plays on the stereotype that nerds are men who are uncomfortable or inexperienced with women. And yet, immersing the characters in fandom culture allows them to express resilience, persistence, and likability through a social context of pastimes that have become increasingly mainstream in recent years.

Audiences need to relate to a comedy’s core characters. By layering the set dressing with models, action figures, comic books, and posters, the producers and writers of *The Big Bang Theory* establish the characters’ geek “street cred.” In addition, the characters participate in tabletop, online, and console gaming. They not only attend fan conventions (“cons”) but also participate in elaborate costuming (“cosplay”), as illustrated in figure 2. Details gotten right serve as inside jokes for fans who enjoy seeing their hobbies portrayed on-screen. That authenticity has been reinforced with cameos by, among others, George Takei from the original *Star Trek* television program and films, Katee Sackhoff from the reenvisioned *Battlestar Galactica* series (2004–09), and James Earl Jones and Carrie Fisher from the movie *Star Wars* (1977).

Depicting diverse science

Getting the science right has been another key to the show’s success. From its very first episode, *The Big Bang Theory* has used real science to make the main characters seem more authentic. The writers contribute some of the science content, but

THE BIG BANG THEORY

the scripts also go for review to David Saltzberg, a UCLA astrophysicist and one of the show's technical advisers. He reviews scripts, refines language, suggests props, and fills the whiteboards that decorate Sheldon and Leonard's apartment (see figure 3). Saltzberg also suggests some of the laboratory equipment and research topics. The details add complexity to the set, plots, and characters. They are not intended to teach modern science or increase basic science literacy. Significantly, *The Big Bang Theory* offers a broader range of specialties, experiments, and settings than do most popular-culture depictions of science.

To allow the actors in *The Big Bang Theory* to perform scientific conversations convincingly, scripts contain a pronunciation guide. According to an interview given by Galecki, as the show has turned in later seasons to exploring the characters' relationships, the actors have had fewer technical terms to memorize. But in the early scripts, the pronunciation guide could be more than a page long. The scientific jargon can function as technobabble. But fans who do recognize the equations on the whiteboards may notice that they relate to the episode's plot. For instance, in an episode from the show's first season, whiteboards displayed equations related to time dilation. The plot of that episode had the four main male characters purchasing a full-sized prop from the 1960 movie *The Time Machine*; the production still on page 41 shows the guys' evident delight in their purchase.

Authentic scientific details help *The Big Bang Theory* to depict particular scientific subfields and the biases that some scientists have. Sheldon, a theoretical physicist who works with equations and theories but not with any physical apparatus, sees a fundamental difference between his work and Leonard's experimental research. Conversely, Leonard teases Sheldon about some of the conclusions that theoretical physicists have reached. In the pilot, for instance, Leonard criticizes the multiple extra dimensions postulated by string theorists: "At least I didn't have to invent 26 dimensions just to make the math come out." When Sheldon retorts, "I didn't invent them. They're there," Leonard asks incredulously, "In what universe?" Sheldon's reply, "In all of them. That is the point," serves both as a punch line and an insider's reference to string theory. Sheldon regularly dismisses microbiology and neuroscience, the respective fields of Bernadette and Amy, as less significant than physics—that is, less intense, less difficult, and less demanding. To lay viewers, Sheldon's opinions might seem to be extreme and impolitic, a reflection of his characteristic lack of social grace.

The Big Bang Theory also contains a running joke about the historic rift between scientists and engineers. In the first season, Sheldon expresses the sentiment with characteristic comic bluntness as he enters Howard's lab: "Engineering, where the noble, semiskilled laborers execute the vision of those who think and dream." He says, surveying the room, "Hello, Oompa Loompas of science!" The hierarchical distinctions between different kinds of scholarly labor are reinforced by the scientist characters who repeatedly address Howard, with emphasis, as "Mister" Wolowitz. Notwithstanding such accomplishments as a master's degree from MIT and selection to fly to the ISS, Howard is constantly reminded throughout the series that he lacks a PhD.

The portrayal of ethnic and racial diversity among scientists

remains limited. Although Howard and Raj are Jewish and Indian, respectively, the show does not reflect the presence of other racial or ethnic diversity in scientific fields. Nonetheless, the presentation of a nonhomogeneous social group of scientists linked through their common workplace, the labs at Caltech, reflects the reality for most people working in academic science.

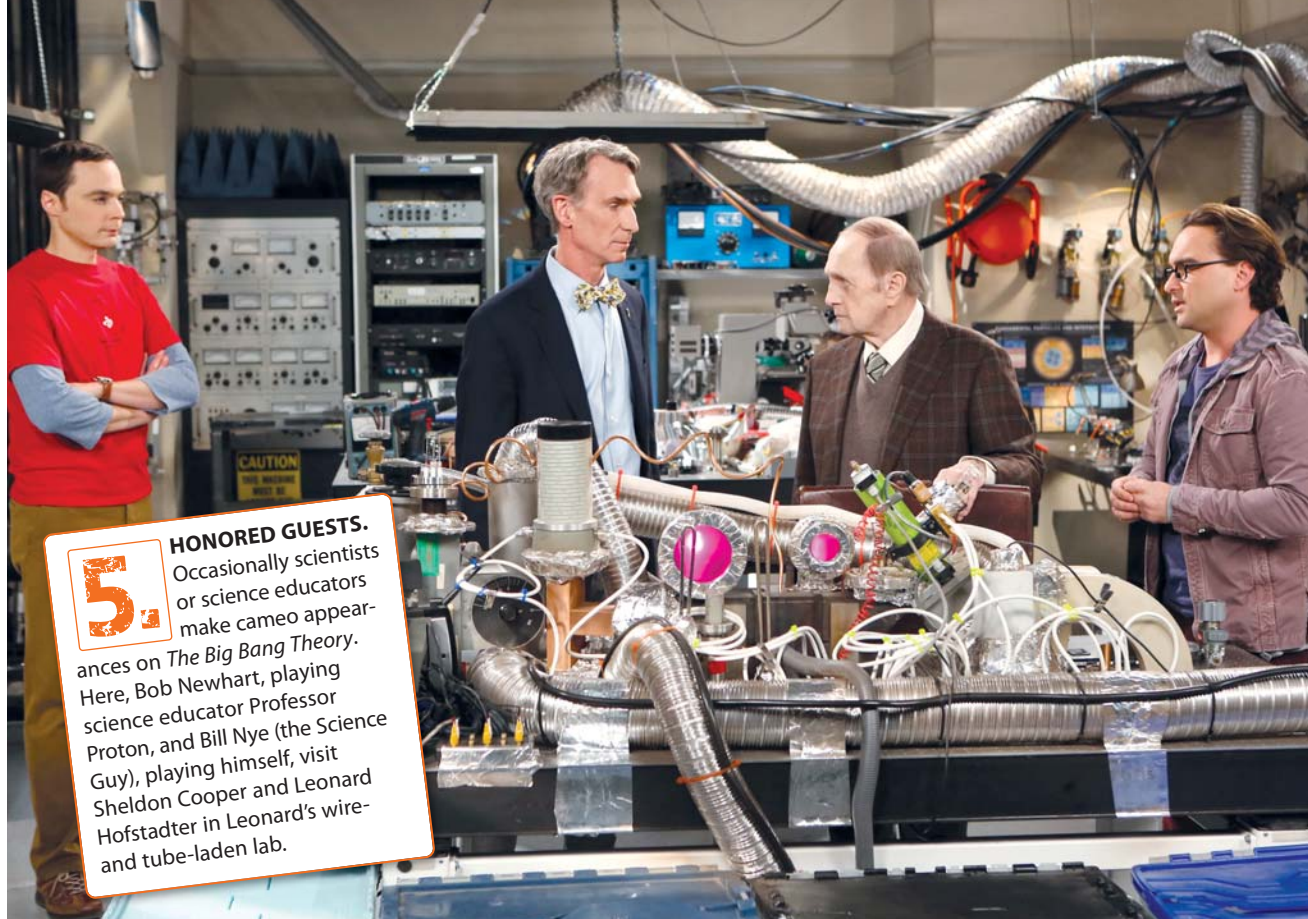
Come for the breasts, stay for the brains

From the beginning, *The Big Bang Theory* has included women scientists. But they have been caught between their functions as supporting characters for the male leads and depictions of women as working scientists. In the show's first season, actor Sara Gilbert appeared as the recurring character Leslie Winkle, an experimental physicist working in the same laboratory as Leonard. In response to Penny's surprised exclamation at meeting her—"Wow, a girl scientist!"—Winkle sardonically replied, "Come for the breasts, stay for the brains." The character served as an antagonist to Sheldon and an on-again, off-again lover to Leonard. Ultimately she breaks up with Leonard because he supports Sheldon, not her, in a scientific argument. As a woman who manages her own sexual needs and remains independent, the Leslie Winkle character breaks some female stereotypes even as she conforms to scientist ones, being acerbic and unpolished.

Adding the characters Amy Farrah Fowler and Bernadette Rostenkowski, who first appeared in the show's third season, expanded the potential for depicting women scientists as more than stereotypes. (Figure 4 shows Amy in her lab, visited by Sheldon.) Because Mayim Bialik, who plays Amy, actually holds a PhD in neuroscience from UCLA, she took on the additional behind-the-scenes role of working with Saltzberg to review the biological science appearing on the show. The women scientists in *The Big Bang Theory* consistently fall victim to what historian of science Margaret Rossiter has called "the Matilda effect," the tendency to have their work devalued or co-opted by male colleagues. Sheldon's general disparagement of their research interests has already been discussed. But the attitude identified by Rossiter can be seen throughout the program.

In fact, the writers directly suggest in several plot developments that women's success could justifiably threaten men. In the finale to season 4, Bernadette receives her PhD, lands a good job, and celebrates by buying Howard a Rolex watch. The expensive gift highlights the disparity between their statuses and disrupts their relationship. The season cliff-hanger plotline reflects not only Howard's insecurity, an aspect of the nerd stereotype, but also an assumption that viewers would see his reaction as understandable gendered behavior. The depiction of women as scientists does not outweigh the program's reliance on stereotypes of male–female relationships to drive much of its comedy, especially in later seasons.

By the show's sixth season, however, the writers seemed to have better realized some of the comedic potential of strong female characters. After Sheldon, Leonard, Howard, and Raj fail to encourage a classroom of young women to consider careers in science, the guys appeal to the women in their lives. Although Amy and Bernadette have spent the day with Penny at Disneyland getting makeovers, they save the day by speaking to the assembled schoolgirls via speakerphone about the importance of women pursuing science—even as, unbe-



5.

HONORED GUESTS.

Occasionally scientists or science educators make cameo appearances on *The Big Bang Theory*. Here, Bob Newhart, playing science educator Professor Proton, and Bill Nye (the Science Guy), playing himself, visit Sheldon Cooper and Leonard Hofstadter in Leonard's wire- and tube-laden lab.

knownst to their young audience, they are dressed head to toe as Disney princesses.

Academic culture and scientist stars

For all of its attention to scientific details and scholarly hierarchies, *The Big Bang Theory* has an odd and perhaps deliberate blind spot: It grossly misrepresents the working structure and practices of academic science. A few examples illustrate the lack of authenticity concerning academic culture.

In the first season, Sheldon gets fired from Caltech for insulting the department chairman, but he then receives his job back after he reluctantly apologizes. Academics might believe that Sheldon could be fired quickly, but they will wonder if any university would refill a vacated research line that easily—with the previously fired person no less. Five episodes later, Sheldon derides speaking at an academic conference as “popularizing.” In reality, most working scientists understand conference presentations to be an inextricable part of their professional work lives. In the sixth season, after an old professor dies, Sheldon, Leonard, and Raj compete for the newly opened tenured professorship by awkwardly wooing tenure committee members—even at the funeral. *The Big Bang Theory* repeatedly ignores the reality of academic university life in favor of funny plot devices.

Because *The Big Bang Theory* takes its science seriously, however, it has procured real science and technology product placements, including the occasional issue of *PHYSICS TODAY*, and it has attracted as guest stars practicing scientists and science educators who can appear on the show without worrying that the association would jeopardize their reputations. Numbered among them are cosmologist Stephen Hawking, astrophysicist and director of New York City's Hayden Planetarium Neil deGrasse Tyson, string theorist and science author Brian

Greene, Nobel Prize-winning astrophysicist George Smoot, NASA space shuttle astronaut Mike Massimino, and *Apollo 11* astronaut Buzz Aldrin. Other cameos include turns by science educator Bill Nye (the Science Guy; see figure 5) and National Public Radio science reporter Ira Flatow—although only by voice, as befits a radio star.

The fandom has become reciprocal. NASA directly supported the plot line about Howard going to the ISS. The agency provided spaceflight details to enhance the final episode of the fifth season, in which Howard launched into space aboard a Russian *Soyuz* spacecraft. The engineer's stay at the ISS became a major story arc in the next season, not, as originally planned, a mere plot point that was supposed to be resolved during the interseason break. Because of the show's reputation for paying attention to scientific detail, NASA officials saw supporting the program as a creative way to foster public interest in the ongoing ISS mission. In turn, show creator Lorre attended the Mars Science Laboratory (MSL) *Curiosity* landing viewing at the Jet Propulsion Laboratory (JPL) in Pasadena, California, as a guest of NASA. After *Curiosity* successfully arrived at Mars in 2012, the entry, descent, and landing group of MSL visited the set of *The Big Bang Theory* and sat for a picture on the famous couch in Sheldon and Leonard's living room. The visit reflected a moment of public relations blindness, however; JPL brought only men to the set, even though the MSL team included both men and women.

Revenge of the nerds

As a character-driven situation comedy, *The Big Bang Theory* has both played with and broken down the expected stereotypes of nerds and scientists. In doing so, it tapped into the interests of its scientifically literate, fanboy-friendly audience. The show became a hit at a time when, in broad terms, nerd-

THE BIG BANG THEORY

dom found new popularity. When *Curiosity* touched down on the Martian surface, the event was carried live on the big screens in New York City's Times Square—at 1:31am. As the crowd watched, it broke out into chants of "Science! Science!" Whether those cheers were self-consciously ironic or not, crowd members recognized that they were standing in the street in the middle of the night to watch planetary science happen in real time.

Public awareness of science and technology has changed radically in the past 10 years. The concerted effort to promote science, technology, engineering, and mathematics courses at all levels of education has resulted in dramatic increases in enrollment to study in those fields at colleges and universities. During the past decade, technology entrepreneurs such as Steve Jobs, Bill Gates, Tim Berners-Lee, Elon Musk, and Mark Zuckerberg became household names, and some of them became incredibly wealthy. *The Big Bang Theory* capitalized on the new enthusiasm for science and technology by offering an award-winning situation comedy that features as its main characters a diverse group of working scientists.

As a program that treats science and fandom with authenticity and respect—and that successfully entertains—*The Big Bang Theory* has become a desirable place for real scientists and engineers to make cameo appearances. Its depiction of scientists may build on a long history of geeks and mad scientists, but the heart of the show's appeal rests in its affectionate portrayal of scientists, complete with equation-laden whiteboards, and its depiction of nerd culture, presented as somehow inextricably linked to scientific pursuits.

A longer version of this article was originally published in the Journal of Popular Television 3, 75 (2015). I thank Michael Neufeld, David DeVorkin, the Smithsonian National Air and Space Museum's writers' group, and the PHYSICS TODAY reviewers for their excellent feedback on this adaptation.

ADDITIONAL RESOURCES

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Applications must reach NIST by **2 February 2017**. Details are on the Web at: physics.nist.gov/pmg.

For further information contact:

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