Scientists on the Set: Science Consultants and the Communication of Science in Visual Fiction

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By exploring the relationship between the scientific community and the entertainment industry in the construction of fictional films, this paper investigates the impact that fictional representations, created with the assistance of scientists, have on the construction of scientific knowledge and the public understanding of science. I discuss the nature of science consulting on fictional films, including compensation, consultants' role in the filmmaking process, and the scientific elements consultants can impact in the films. By questioning the nature of fictional "accuracy," I demonstrate that the scientific community's focus on "scientific accuracy" in fiction is flawed. Fictional film naturalizes both "accurate" and "inaccurate" science by presenting both as "natural" via a perceptually realistic framework.

1. Introduction

For the past 20 years, much of the research into the "public understanding of science" has focused on the relationship between science and the mass media. The phrase "mass media" is very broad: it covers everything from newspapers and magazines to documentary television programs, fictional films, and digital media's ever-expanding domain (McQuail, 2000). Such a wide variety of formats makes generalizations about media issues in the public understanding of science difficult. To provide a more complete understanding of science communication as it relates to the public understanding of science, it is helpful to examine the portrayal of science in specific media formats, such as news and entertainment. Thus far, studies of science and the mass media have concentrated primarily on news media. Although news media studies provide a good understanding of the negotiations needed to produce science news, they say little about the negotiation process in entertainment media.

Several recent studies examined the flow of science information in the context of visually based nonfictional entertainment media (see Kirby, 2003). This research complements the work done on news media in showing how popularization activities are not just about "sharing" scientific knowledge but are a component in the *making* of scientific knowledge. These analyses also reveal what is unique about communicating science through entertainment media by showing that the constraints imposed by entertainment media, even "reality-based" texts such as documentaries and nature films, are quite different from those

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affecting science in the news media. Despite the value of these academic works in expanding our views of science communication, it is not clear if these results will hold for the communication of science in purely fictional, visually based entertainment media.[1] Given the enormous audience for fictional films and television, it is important to broaden our conception of "public understanding of science" to include fictional entertainment media.

Many scientists, in fact, believe that the communication of science in visually based fictional media texts, such as television and cinema, has been detrimental to the public understanding of science (Van, 1995; Hawkes, 1997; Hofstadter, 1998; *USA Today*, 1999; Leslie, 2002; Tyson, 2002). These scientists feel that more often than not the science in these texts is factually wrong, that scientists are portrayed as evil or socially apathetic, and that scientific knowledge is inherently dangerous. The view among fictional science's critics is that science in fictional films and television negatively affects public attitudes toward science. Physicist Robert Park, for example, was angry about the representations of scientists in films such as *Honey, I Shrunk the Kids* (1989) and said that he feels that these depictions contribute to a public perception that "scientists are people who fiddle around in basement labs doing crazy things" (see Van, 1995: C1). According to Park, the fictional portrayal of scientists "is not a healthy situation or a trivial concern." The National Science Foundation (NSF) agrees with Park that fictional portrayal of science is harmful to the public understanding of science. According to the NSF's *Science & Engineering Indicators—2000*, fictional media have corroded the public's critical thinking skills and have hindered scientific literacy:

> The amount of information now available can be overwhelming and seems to be increasing exponentially. This has led to "information pollution," which includes the presentation of fiction as fact. Thus, being able to distinguish fact from fiction has become just as important as knowing what is true and what is not. (National Science Foundation, 2000: 8–31)

The NSF's concern may not be trivial given the amount of science communicated through fictional media. George Gerbner, for example, found that 7 out of every 10 programs on television between 1973 and 1983 contained images of science and technology (Gerbner, 1987). Likewise, Andrew Tudor's study of 990 horror films showed that the most frequent type of threats (251 out of 990, or 25%) in horror films are scientific in nature (Tudor, 1989: 21).[2]

There are also indications that fictional portrayals of science have an impact on public attitudes toward science. Although the difficulties and limitations of media effects studies are well documented (Gauntlett, 1985; Bryant and Zillmann, 1994; Nightingale, 1996; Shanahan and Morgan, 1999), several empirical studies of science in the media suggest that fictional representations of science on television can have an influence on public attitudes toward science. Gerbner's work on cultivation analysis shows that individuals who frequently watch television are more likely than infrequent viewers to lack confidence in the scientific community, believe that science is dangerous, be mistrustful of scientists, and believe that a career in science is undesirable (Gerbner et al., 1981). In the last decade, audience research studies undertaken by communications researcher Glenn Sparks suggest that television's positive depiction of paranormal subjects has an effect on viewers' attitudes toward the paranormal (Sparks et al., 1994; Sparks et al., 1997; Sparks, 1998). For example, those who regularly watched fictional shows such as *The X-Files*, *Touched by an Angel*, and *Millennium* were significantly more likely than those who did not watch these programs to endorse paranormal beliefs (Sparks et al., 1994). Sparks' finding holds up even after accounting for age, education, and other variables. While the existing evidence does not

permit us to claim that fictional entertainment media shape public opinion, it is likely that the presentation of science in fictional narratives provides an environment in which preexisting attitudes are readily cultivated and reinforced (Shanahan and Morgan, 1999).

One of the ways in which scientists have tried to combat the negative impact of fictional media is by writing "The Real Science of . . ." style articles about popular films and television programs (see, for example, Nicholls, 1983; Dubeck et al., 1994; Krauss, 1996; Desalle and Lindley, 1997; Andreadis, 1998; Jenkins and Jenkins, 1998; Stocker, 1998; Cavelos, 1999; Simon, 1999; Yaco and Haber, 2000; Glassy, 2002). These types of analysis involve a critique of the "accuracy" of scientific content in fictional texts, such as *Star Trek* and *The X-Files*. The problem with these studies is that they focus on a narrow view of public understanding of science as an "understanding of facts." The point of fictional media is not to devise "accurate/educational" communications about science, but to produce images of science that are entertaining. These images have an impact on Americans' conceptions of science by either encouraging excitement or instilling fear about science and technology. It is important to note that "science" in the context of this essay is not defined as substantive content; rather it is defined as a genre, theme, or conventional representation in fiction. Fictional depictions of science encompass more than just a collection of "facts." They include the significant elements in the fact-producing process called science—a body of knowledge, the methods of science, the social interactions among scientists, laboratory equipment, etc. In addition, fictional depictions of science, especially in visual media such as television and film, involve the production and presentation of an *image* of science, whether or not the "science" has anything to do with "real science."

Unlike studies of scientific content in entertainment media, studies of science within a cultural framework do focus on a broad definition of "science" as a theme of fiction. Cultural interpretations of science in fictional media have been the most active area of research into science in fiction over the last 10 years, and have provided a gauge of social concerns, social attitudes, and social change regarding science and technology (see Kirby, 2003). However, these studies are essentially based on textual analyses and offer little insight into the *production* of the texts. To truly understand fiction as a mode of science communication, and its role in the public understanding of science, it is necessary to understand who is communicating science through these texts and why they choose to communicate science in a particular way.

Scholarship related to science and the production of visual fiction is limited (Yandetti, 1978; Reingold, 1985; Turow, 1989; Mitman, 1999). As discussed above, most academic works eschew the communicative *process* in favor of describing *content*. Yet, it is the mediation among scientists, the entertainment industry, and audiences that produces the representation of science in entertainment media. To elucidate the relationship between the construction of fictional science, the scientific process, and the public understanding of science, this essay will focus on the interactions of key players in the production process. A similar approach has been successfully applied to the communication of science through news media, where researchers have analyzed the interactions between scientists and journalists (see, for example, Friedman et al., 1986; Nelkin, 1987). With fictional films and television programs, the analogous case is situations in which scientists act as consultants to the entertainment industry. Using examples of science consultants for fictional films culled from interviews with science consultants, both published and ones conducted by me, I discuss the nature of science consulting on fictional films, including compensation, consultants' role in the filmmaking process, and the scientific elements consultants can affect in the films. In addition, I show how the representation of science in fictional media impacts the public understanding of science and the construction of scientific knowledge. While I

occasionally discuss older films, I predominantly explore recent films. Older films are useful to provide a context, or to illustrate certain points. However, my concern here is with the contemporary state of science communication. Therefore, I will concentrate on films produced within the last 10 years.[3]

2. Compensation for consulting

The motivation for filmmakers to utilize science consultants is clear. Scientific knowledge holds a place of privilege in society, and the scientific expert is often used to legitimate one's own views. By using scientists as consultants, filmmakers can claim legitimacy for their visions of science. The publicity value of science consultants is evident in the fact that filmmakers frequently highlight scientists in a film's press and marketing material. Studios encourage scientists to speak with the press about their film work; scientists also often attend press conferences surrounding the films. In the jargon of Chris Toumey, filmmakers are "conjuring science" by using science advisers as promotional devices (Toumey, 1996). Studios value consultants during promotion because they believe scientists add "realism" to a film. By bringing in scientists, filmmakers can borrow their scientific authority to claim that their films depict "reality."

The association between "realism" and science consultants follows from recent trends in film production. According to film theorists Julia Hallam and Margaret Marshment, the rise of the blockbuster "spectacle" film in the 1980s and 1990s has resulted in a renewed emphasis on film "realism." They argue that a special-effects-derived spectacle "has to be sufficiently credible to be possible in terms of what constitutes a rational possibility of the unknown" in order to maintain audiences' interest in a film (Hallam and Marshment, 2000: 78). Filmmakers bring scientific experts into the filmmaking process in order to make their films "sufficiently credible," and thus avoid audience disenchantment. In fact, the rise in realism mapped by Hallam and Marshment corresponds to the increase in the number of science consultants in the 1990s I have previously shown (Kirby, 2003). Filmmakers' need for "realism" has turned science consulting into a flourishing business. Indeed, there is so much demand for scientific verisimilitude in visual fiction that several scientists, such as Donna Cline and Steven Kutcher, have turned to consulting on a full-time basis. In addition, there are now several companies in the US (e.g., Takeoff Technologies in Pasadena, CA) and in Europe (e.g., The Dox in Munich, Germany) dedicated to connecting scientists with filmmakers and television producers.[4]

While the motivation for filmmakers to use scientists is clear, what are the reasons that scientists work on fictional films? There are a multitude of motivations for scientists to consult—fame, financial gain, promotion of ideas, amusement, or popularization. Science advocacy is certainly one reason scientists choose to consult. Many scientists view consulting as an opportunity to counteract the overall negative portrayal of science described above. For example, virologist Anne Simon, the official consultant on *The X-Files* and its film version, claims that she does not request a fee for any of her work because she "sees her [Simon's] consulting work as a service to science" (see Jerome and Duffy, 1998). Likewise, Carl Sagan felt that a better public understanding of science could be facilitated through accurate depiction of science in media (Sagan, 1995). It was this belief that motivated him to make sure that filmmakers correctly portrayed the science in the film adaptation of his novel *Contact* (1997) (Davidson, 1999). Other scientists saw fictional films as a means for promoting scientifically based social movements. Several historians have documented the participation of scientists in fictional propaganda films used to advance scientifically based

social movements or health issues, most notably eugenics (Pernick, 1996). Activist scientists were also involved in the rash of "environmental" science fiction films in the 1970s, including *Silent Running* (1971), *Soylent Green* (1973), and *The China Syndrome* (1979). Such direct activism by scientists in fictional films has been rare since the 1970s. In one notable exception, primatologist Roger Fouts worked with the actors who played apes in *Greystoke: The Legend of Tarzan, Lord of the Apes* (1984). Fouts got involved in the project in order to end the use of primates by the entertainment industry by proving that actors in costumes could adequately portray apes (Fouts, 1997).

While a desire to portray "accurate science" or to promote a particular cause may motivate some scientists, it is also true that many consultants are well compensated financially for their consulting work. Comparative anatomist Stuart Sumida of California State University at San Bernardino consulted on several films, including *The Lion King* (1994), *George of the Jungle* (1997), *The Prince of Egypt* (1998), *Stuart Little* (1999), *Hollowman* (2000), and *Stuart Little 2* (2002) (see Bradley, 2001). Unlike many other consultants, who do not ask for any financial compensation and claim to consult on fictional films in order to "promote science," Sumida charges a consulting fee of between $100 and $200 per hour. Although Sumida receives direct payment for his services, there are numerous examples in which science advisers accept grants to support their research in lieu of direct financial payment. For example, paleontologist and artist Douglas Henderson, who acted as a consultant on *Jurassic Park* (1993) and *Dinosaur* (2000), mentioned that his motivation for working on these films was to get "very well paid" in order to "free me later to take the time to do the work I want" (Henderson, personal communication). In essence, his work on fictional films provided him with the funds he needed to support his work in paleontology. Likewise, geneticist Wayne Grody, who has consulted on several films, including *The Nutty Professor* (1996), claims that "in lieu of a consulting fee, the studios donate to [my] research at UCLA" (Schmidt, 1999).

In another instance, filmmakers sought out Ken Suslick of the University of Illinois at Urbana to help them on their film *Chain Reaction* (1996). The plot of the film centers on an alternative, low-cost, pollution-free fuel source involving sonoluminescence—the conversion of sound energy to light energy. The set director on the film learned of Suslick's sonoluminescence research and sought him out for advice on building a "realistic-looking" ultrasound laboratory. Suslick did not receive any direct financial payment for his advice to the filmmakers. Instead, Suslick's department within the School of Chemical Sciences received a grant from 20th Century Fox as compensation for his advice and for the use of old laboratory equipment (Reese, 1997).

The exchange of advice for research funding is not limited to recent instances of science consulting. For example, German filmmaker Fritz Lang hired well-known rocket scientist Hermann Oberth to consult on his motion picture *Frau im Mond* [*Woman in the Moon*] (1929).[5] At the time, Oberth was a leading figure in the German space movement and author of the highly influential 1923 book *Die Rakete zu den Planetenraumen* (*The Rocket into Planetary Space*). Although Oberth was a world-renowned rocket scientist, he desperately required additional funding for his research (Ley, 1968: 115). In exchange for working as scientific adviser for the film, Oberth received money from the film's production company, Universum Film AG (UFA), and ultimately money out of Lang's own pocket, to conduct experiments on his Model B liquid-fuel rocket. In addition to working on the film, Lang also hired Oberth to build a working rocket to be launched at the film's premiere in October 1929.

Oberth used the money he received from Lang to design and build test rockets. Nevertheless, he was unable to build a working rocket in time for the film's premiere, and

UFA pulled its funding. Four months after his failure to produce a working rocket, Oberth explained what happened to *The New York Times*:

> [They] lost interest in my work after completing, with my aid, a film of a rocket trip to the moon. I more than exhausted the funds they placed at my disposal, and have been obliged to call a halt for the moment. I have already shot off a series of test rockets, however, and if I could have obtained a further subsidy I should have been ready to fire the first rocket into space now. (*New York Times*, 1930: 3–2)

Despite Oberth's complaints, if it were not for the funds provided by Lang, he would not even have been able to produce the initial test rockets. In fact, Oberth was so grateful for Lang's help in funding his research that he dedicated his 1928 book *Ways to Spaceflight* to Lang (Freeman, 1993: 49). Without Lang's initial funds he would still have been trying to convince people of the feasibility of rocket travel solely through theoretical manipulations. As it was, the test rockets he produced while working on the film helped convince others to provide the funding needed to continue his research (Freeman, 1993: 58).[6]

Based on the available evidence, science consultants are far more likely to accept research funds, or no compensation at all, rather than actual payment for their services. One of the reasons for this situation is the unwillingness of scientists to take money for what they consider a "public service." Many of the consultants I researched felt it was their "duty" as a scientist to impart knowledge to an uneducated public, including filmmakers, and that it would have been "unethical" for them to take money for this activity. For example, two of the consultants for the 1922 gland-based horror film *A Blind Bargain* (1922) felt that it would be "disreputable" for "medical researchers" to accept payment for their services, and they even requested that their names not be included in publicity material (see Riley, 1988). Likewise, Donald Francis of Genentech, Inc., who is most famous for his work on an AIDS vaccine, refused financial payment for his work as technical adviser for the film *Outbreak* (1995), accepting as compensation "only that his 17-year-old son, Oli, be allowed to observe the filming" (see Ganahl, 1995: 1E). Francis' example underscores the conflict that science consultants face. On the one hand, they believe that as scientists they should give scientific advice freely to anyone who seeks knowledge. On the other hand, they are providing a specialized service for filmmakers and believe they should receive compensation of some type. To resolve this tension, consultants have come up with other forms of compensation that do not involve direct financial payment. In this regard, consultants who accept research funds rather than salary or consultation fees perceive that this action does not compromise their "ethics," because the money will not go into their pockets but will go toward the production of "new knowledge."

Unlike individual consultants, scientific institutions have never shied away from collaborations with fictional filmmakers or other entertainment media. Cooperation between scientific institutions and fictional filmmakers can be traced all the way back to 1916, when the Selig Zoo in Los Angeles allowed filmmakers to use its animals for the dramatic film *Thou Shalt Not Yet Covet*. Production companies reimburse research institutions for the use of their facilities for filming or for access to their scientists. Argonne National Laboratories, for instance, benefited financially by allowing 20th Century Fox to use its facilities while filming *Chain Reaction* (Borucki, 1996). In fact, 20th Century Fox utilized several scientific institutions while filming *Chain Reaction*, including Argonne, the Field Museum in Chicago, the Museum of Science and Industry in Chicago, and Yerkes Observatory in Wisconsin. The Field Museum also served as a set location in 1996 for Paramount Pictures' horror film *The Relic* (1997).

Large and prominent research institutions have even set up divisions devoted to seeking

out relationships with the entertainment industry. The National Aeronautics and Space Administration (NASA), for example, established its "Entertainment Industry Liaison" in the late-1960s (Lewenstein, 1994). They have recently been intricately involved in the production of several films, including *Deep Impact* (1998), *Mission to Mars* (2000), and *Space Cowboys* (2000) (Yam, 1998; Dawson, 2000; Canizares, 1999). On each of these films NASA provided technical advice on the sets, access to its scientists for scientific advice, script analysis, and the use of facilities and equipment. NASA even authorized the use of its logo by a fictional text for the first time in *Mission to Mars* and *Space Cowboys* (Dawson, 2000). Since the government prevents federal agencies from profiting from outside collaborations, producers reimburse NASA for the use of its facilities and scientists, but the agency does not profit from its Hollywood arrangements. While they may not receive financial benefits, NASA views fictional consulting as an excellent vehicle to promote its agency's mission and its scientific projects. According to Warren Betts, *Deep Impact*'s director of marketing, NASA actually approached him about working on the film (Yam, 1998). In an interview with *Mail & Guardian Online*, Bobbie Faye Ferguson, a NASA spokesperson, explained NASA's reasoning for why it seeks involvement in fictional enterprises:

> One of the things we do is try to increase awareness of space and spatial exploration . . . Right now there is a lot of interest in a manned mission to Mars. There is no official manned mission listed, but that's not saying there's not a lot of people who aren't very excited about it. I certainly think that participating in films that reach a large number of people, and that are feasibly fictional, increases the awareness of space and the future. (Ferguson cited in Dawson, 2000)

Despite its belief that involvement in fictional media is good publicity, NASA does have limitations on its willingness to become involved in fictional productions. According to Matthew Golombek, the lead scientist on NASA's 1997 Mars Pathfinder mission and a consultant on *Mission to Mars*, NASA would not participate in the production of *Red Planet* (2000).[7] Golombek states that NASA balked at a scene in *Red Planet*'s script, which included the shooting of an astronaut by another astronaut. NASA felt the scene would damage their image and asked the filmmakers to remove it before they would consider consulting on the film. Golombek notes, however, that NASA did approve the script for *Mission to Mars*, even though the film features the "face on Mars," a geographic feature that NASA repeatedly denies.

3. The role of science consultants in fictional science's depiction

A comprehensive literature review identified only a few studies on the production aspects of visually based fictional media containing science.[8] All these works argue that entertainment media presentations of science reveal a tension, not only between the narrative forms of media and those of science, but also between the needs of the entertainment industry and those of the scientific community. No matter what level of control science consultants have over the finished product, they are still part of the filmmaking process and, as such, will have some "authorship" in the way the science is depicted.[9]

Scientist and filmmaker interactions

Although they may be "authors" on the film, it would be a naive view to believe that scientists have as much control over the science in a film as the director or the production

designer have. Filmmaking is a chaotic process that involves hundreds of people who have a limited amount of time and money to bring a film to its completion. Oftentimes, "scientific accuracy" takes a back seat to issues of filmability, budget, and drama. Robert Heinlein, technical adviser on *Destination Moon* (1950), summed up an overriding constraint faced by scientific advisers, "Realism is confoundedly expensive" (Heinlein, 1992: 123). Nearly every scientist, in fact, has a story about a piece of scientific advice that filmmakers, for whatever reason, did not include in the film. For example, Tom Kuiper of the Jet Propulsion Laboratory (JPL) and Linda Wald, a graduate student at UCLA, worked with computer and video supervisor Ian Kelly of Kelly's Eye to develop computer displays and audio of an "alien" radio signal for the movie *Contact*. While Kuiper was happy with most of the science in the film, he was disappointed with the sound of the alien signal:

> One thing did not turn out as we wished. I urged Ian to explain to the sound people how the pulsed audio signal should sound, basically a pure tone. Ian was not successful in convincing them of that because such a sound is not very interesting. So, for the prime number sequences, we ended up with the sound of a giant [who is] munching corn flakes. (Kuiper, personal communication)

In the film, the main character's discovery of the alien signal is a very powerful scene, and the sound used by the sound designers effectively conveys a combination of exhilaration and spookiness. After watching the film it is easy to understand why the sound designers rejected Kuiper's scientific advice and went with a dynamic sound over a pure tonal sound. Kuiper's experience is certainly not unique, and more often than not, scientists reveal in interviews recommendations that filmmakers chose to disregard.

Kuiper's example highlights the fact that these scientists are only "advisers" and that filmmakers have various reasons for accepting or rejecting their advice. However, it is important to keep in mind that they are hiring consultants to add "reality" to their production. It is wasted time and money for a filmmaker to hire a scientist only to ignore all their advice. There are an abundance of examples where scientists' advice changed the presentation of science in a film. In several cases, scientists expressed astonishment at how much the filmmakers paid attention to them. Chris Luchini of JPL, for instance, consulted extensively on the film *Deep Impact* and said he "was surprised at how much interest there was in getting it right" (see Goldman, 1998: 31). Luchini understood the filmmakers' need for "dramatic license," but still felt that filmmakers adopted many of his suggestions:

> Luchini found the filmmakers receptive to the science and willing to modify the script for accuracy. For instance, the original description of the comet—which is basically a dirty snowball—was incorrect. "They had the density higher than uranium," Luchini says. "A lot of details like that were flat-out wrong" but were subsequently corrected. (Luchini quoted in Yam, 1998: 22)

Luchini's account mirrors those told by many recent consultants in interviews. Most consultants understood filmmakers' constraints, but they also were impressed with filmmakers' efforts to accommodate their recommendations.

An example of the process of science consultation will illustrate the negotiations among consultants and filmmakers when it comes to presenting science (see also Shay and Duncan, 1993; Grazulis, 1999; Anderson, 1998). Journalist Mary Roach sat in on a pre-production meeting between Donna Cline and *Outbreak*'s filmmakers. Present at the meeting were the most influential filmmakers, including the director, producers, and production designers. Cline's job during the meeting was to present the epidemiology of the fictional Ebola-like "Motaba" virus, including its morphology and its effect on victims. At one point, Cline

described the symptoms present during the second stage of a hemorrhagic fever to the film's director, Wolfgang Peterson:

> "The eyes are beginning to turn red. We're seeing skin lesions, a red blush through the neck and face." Peterson is concerned about his female lead, [Rene] Russo, who gets the virus. "Donna, could this look even kind of beautiful?" Cline is nodding, more to stall for time than from any conviction that second-stage hemorrhagic fever can be beautiful. "You mean for Rene?" Underneath the metal alloy exterior, Cline is scrambling. "Yes, she could look flushed, look . . . excited." (Roach, 1995: 80)

Clearly, Cline must accede to the director's wish not to have his female star covered in "lesions," despite any feelings the consultant had of maintaining scientific "accuracy." Later in the meeting, however, Cline convinced the filmmakers to retain fidelity as far as portraying the virus. Her illustration of an Ebola virus led to this exchange between Cline and an executive producer (EP):

> EP: What I like, what I'd like to play up here is the contrast between the innocuous, healthy tissue and the villainous, evil, writhing virus.
>
> Cline: A virus is . . . They can't actually move.
>
> EP: They can't?
>
> Cline: No, they can't.
>
> EP: Oh. (Roach, 1995: 81)

Had the science consultant not been present at the meeting it is possible that the virus in *Outbreak* would have moved. Certainly the filmmakers could have ignored Cline's advice and designed a writhing virus, but in this case they felt "reality" served the film better. In a sense, Cline is playing a "mediator" role between "reality" and "entertainment." She is educating the filmmakers about "science," but she is also helping them to make an exciting film. In some cases she must acquiesce and tell the filmmakers what they want to hear, but in other instances she feels she needs to stick firmly to "reality." Cline herself sums up the challenges faced by the science adviser when she says, "I'm a fanatic for detail, but I know when to back off. It's a constant assessment of priorities" (see Roach, 1995: 82–83). Of course, the major priority for filmmakers is selling tickets. Therefore, they ultimately decide in each instance whether scientific accuracy or "dramatic license" provides more box office appeal.

4. Science consultants and the presentation of "science" in fictional films

Now that I have identified the role that consultants can play in fictional films, I want to turn to the question of what elements of "science" consultants impact in fictional films. As mentioned above, I do not restrict my analysis to the narrow definition of science as a collection of factual statements about the natural world. Rather, I take a broader definition of science in fiction as a genre or theme that includes all the elements of scientific practice. This definition of "science" follows from Andrew Pickering's definition of "scientific culture," in that he takes scientific culture to denote the "made things" of science, which include "skills and social relations, machines and instruments, as well as scientific facts and theories" (Pickering, 1995: 3). Science consultants can contribute to all the elements of "scientific culture" in terms of the presentation of science in the cinema.

Playing a scientist

Filmmakers frequently call in science advisers to help them portray a filmic "scientist." They expect scientists to advise them on how a scientist would look, behave, and talk in a particular situation. One of the duties of science advisers is to help actors "act" like scientists. Dustin Hoffman, for example, prepared for his role as an epidemiologist in *Outbreak* by spending time with Donald Francis:

> "All I was supposed to do was review the script, but Dustin got way into it . . . We ended up going down [to Los Angeles] for 12-hour script sessions on weekends. He wanted to make sure everything was exactly right." At times, recalls Francis, Hoffman's attention to detail reached weird extremes. "There we were, driving down the freeway, and while he's driving he's also watching me intently, soaking up my gestures like a sponge, barking at his assistant in the back seat: 'Watch that! Write that down!"' (Ganahl, 1995: 1E)

By following Francis around and taking detailed notes of his actions, Hoffman hoped to get an essence of what it was to be a "scientist." While Hoffman's meetings with Francis may have resulted in a more "realistic" version of a scientist on the screen, it is still just Hoffman's interpretation of a single scientist. Likewise, the dress, worksite actions, and speech of a scientist will vary from discipline to discipline; an epidemiologist in *Outbreak* should look and behave much differently than a meteorologist would in *Twister* (1996). Members of *Twister*'s cast spent time with scientists from the National Severe Storms Laboratory (NSSL) to prepare for their roles. According to Helen Hunt, who plays meteorologist Jo Harding, her meetings with "storm chasers" helped her to "discover the psychological motivations" behind her character's obsession with chasing tornados:

> None of the chasers said they were afraid. Some do it for science and some do it for sport, but the pure power of the tornado is just intoxicating to certain people. However, many of them said that they had experiences with a tornado in their youth that affected them deeply, which is very true of Jo. In an attempt to deal with what happened to her, she decided that this thing was after her. She needs to get near it again in order to get healed. (Hunt quoted in production notes for *Twister* (1996), Warner Brothers)

Like Dustin Hoffman, Helen Hunt wanted to find out "what makes a scientist tick," so that she could give a "realistic" portrayal. The importance of portraying "realistic" scientists has meant that even filmmakers on recent horror films, a genre not traditionally associated with portraying "real" scientists, have brought in scientists to work with their actors.[10]

One element that is unique to the behavior of "real" scientists is the use of scientific jargon. In addition to helping actors "act" like scientists, science advisers also assist actors with the pronunciation of scientific words and phrases. For example, on *Outbreak*, Dustin Hoffman and his fellow actors needed help with pronunciation of words specific to molecular immunology, such as "gamma globulin" and "aerosolized" (Roach, 1995: 84). According to an article in the *Los Angeles Times*, several actresses from recent films, including *The Lost World: Jurassic Park* (1997), *Contact*, and *Volcano* (1997), learned how to "techno-speak" with the help of real scientists: "most of the actresses at least talk with someone who usually does it for a living, even if it's just because the expert is around the set" (Willens, 1997). For the general public, which includes filmmakers, scientific language is often perceived as alien and mysterious. One of the actresses in the *Los Angeles Times* article called scientific terminology "techno-babble," comparing it to learning Japanese; while an executive producer on *Volcano* called scientific nomenclature "gobbledygook."

The arcane nature of scientific language adds legitimacy to a film's images and plot,

making it an important component in science-based films. In her seminal work on the science fiction film, Vivian Sobchack says that scientific jargon's incomprehensibility renders it dull, but that its dullness may be an asset, because a "dull and routine language by remaining dull and routine may very well authenticate the fiction in the films' premises or images" (Sobchack, 1997: 154). For Chris Toumey, the importance of scientific language is that it connotes "scientific knowledge" and that it is really knowledge that gives science its authority (Toumey, 1996). This association between language, knowledge, and power helps to explain the use of pseudo-scientific gibberish in many earlier science fiction films. Characters that spout esoteric words demonstrate to the audience that they have powerful scientific knowledge that others do not possess. The more obscure the words, the more powerful the knowledge should be. Filmmakers have to come to realize, however, that false "techno-speak" may do more harm than good. "Techno-speak" that does not ring true with an audience is likely to put them off to the "scientific" underpinnings driving the plot or the images. In addition, the film could receive a backlash from scientists in the form of "The Real Science of . . ." style books and articles that now regularly attend science-based films. Such a critical lashing by scientists undercuts a film's pretensions to scientific "reality" and does not make for good publicity. This is why filmmakers have turned to scientists to help them with their scientific language, and to help their actors pronounce and use words correctly. The rewards of including "real" jargon far outweigh the risks of including impressive sounding but fabricated "techno-speak."

The "look" of science

Science consultants are also responsible for developing the "look" of science in the film. Certainly one component in the "look" of science is the design of scientists' workspaces. Science consultants must answer questions, such as, "What does a dinosaur excavation site look like?", "What equipment would a bio-level 4 laboratory include?", and "What kinds of instruments do volcanologists use?" *Jurassic Park*'s filmmakers, for example, had to design two distinct research spaces for the film, a paleontological dig site and a molecular biology laboratory. While the filmmakers hoped to make their site truly "authentic" by building the set in Montana's Badlands, for budgetary reasons they had to "settle" for filming in the Mojave Desert. Paleontologist Jack Horner was on hand to make sure that the research site conformed to his experiences. According to producer Kathleen Kennedy:

> We brought our consultant on the show, paleontologist Jack Horner, out to the site to make sure we were setting it up realistically; and he said it looked exactly like the environments he had worked in. So we got his stamp of approval. (Kennedy quoted in Shay and Duncan, 1993: 92–93)

In essence, Horner served as the judge of "reality" giving his "stamp of approval" and legitimizing the filmmakers' depiction of "science." For the molecular biology laboratory, the filmmakers relied on laboratory technician Ron Rogge from the University of California at Los Angeles (see Mestel, 1995: 29). To make the laboratory appear "authentic," Rogge ordered equipment both large and small, he prepared "laboratory notebooks" using work on the genetics of *Drosophila*, and he labeled water-filled beakers with the names of common reagents used in molecular biology laboratories (e.g., TAE). Of course, Rogge had to make concessions to the set decorators on several things, such as beakers filled with colored liquids and the placement of a dinosaur hatchery in the middle of a molecular biology laboratory.

Many geneticists applauded the "authenticity" of the molecular biology laboratory setup, despite any changes made to satisfy filmmakers. One scientist, for example, noted the

inclusion of boxes of dust-free tissues, known as Kimwipes, in the laboratory setup. For this scientist, the presence of the easily identifiable green and white boxes, found in every molecular biology laboratory, told him that the filmmakers "knew what they were doing" (Mestel, 1995: 28). In reality, the presence of the Kimwipes was due entirely to the fact that Rogge, a laboratory technician, designed the laboratories. In terms of portraying an "accurate" laboratory, the filmmakers were actually better served by having the "invisible technician" assist them rather than an actual "scientist."[11] Most science consultants are high-profile scientists, who may not have done laboratory work for years, while a laboratory technician would be intimately familiar with all the minute details of a laboratory setup.

In many cases, consultants provide filmmakers with the material objects needed to portray research sites accurately. As mentioned earlier, scientific institutions frequently allow filmmakers to film inside their facilities. For instance, many recent films, including *Apollo 13* (1995), *Deep Impact*, *Armageddon* (1998), and *Space Cowboys*, were filmed inside NASA's Kennedy Space Center. Scientific supply companies also frequently lend or give equipment to filmmakers for use on their laboratory sets. For example, several supply companies donated equipment for the laboratory set of *Jurassic Park*, including Fisher Scientific and Precision Scientific (*Genetic Engineering News*, 1993: 16). The companies considered the donations good publicity, as they realized that thousands of biologists would see the film. Individual scientists have also donated equipment to filmmakers. As mentioned previously, Ken Suslick helped *Chain Reaction*'s set designer conceive a sonoluminescence laboratory by donating old laboratory equipment. Scientists have donated or lent objects other than laboratory equipment to filmmakers. For example, in exchange for "tickets to the premiere in Sacramento," University of California at Davis epidemiologist Frederick Murphy provided his Ebola micrographs for *Outbreak*'s filmmakers (Henahan, 1996).

"Factual" content and the inclusion of disputed science

While the portrayal of scientists and scientific workspaces is important to filmmakers, filmmakers mainly hire scientists in order to ensure that their portrayal of the natural world corresponds to scientific laws. At a basic level, film studios bring scientists on to fictional films in order to check "facts." The makers of *Dante's Peak* (1997) had questions about how to portray a volcano nearing eruption, so they called volcanologists John Lockwood and Norman Macleod, and seismologist David Harlow. To make sure their depiction of the surface of Mars was "correct," *Mission to Mars*'s filmmakers turned to the head of the Mars Pathfinder mission. To visualize a "blue giant star" in *Supernova* (2000), the filmmakers contacted Jacklyn Green, who heads up JPL's "Extraterrestrial Materials Simulation Lab." The type of scientific fact filmmakers require ranges from very specific subjects, such as the morphology of a "death's head" moth in *The Silence of the Lambs* (1990), to very broad topics, such as generalized dinosaur behavior in the *Jurassic Park* films.

In most instances, the "facts" that filmmakers ask science consultants about are questions about the natural world for which there is a consensus within the scientific community. The generalized termite social structure described in *Mimic* (1997) or the roiling ash-flow clouds that travel down the side of an erupting volcano as shown in *Dante's Peak*, for example, are scientific facts that have little or no disagreement within the scientific community. Although consultants are usually asked to clarify science that is uncontroversial, it can also be the case that filmmakers ask scientists about natural phenomena for which there is not an established "correct" explanation (see Kirby, 2003). For example, the depiction of *Tyrannosaurus rex* in *Jurassic Park III* (2001) as a scavenger corresponds to consultant Jack Horner's "accurate" representation of *T. rex*. In cases of disputed science,

like the feeding habits of *T. rex*, the consultant's version of "scientific fact" is not necessarily every scientist's notion of "fact." During "science in the making," several competing visions of nature make claims to representing "fact." A fictional film, however, allows for only one of these visions to be presented as "natural" on the screen. In the case of disputed science, the consulting scientist is more likely to get their vision of "fact" into a film.

5. Conclusion and discussion

Traditionally, "public understanding of science" issues have been couched in terms of scientific literacy, essentially following what has been referred to as the "deficit" model. Under this model, scientists dispense scientific knowledge, usually through the mass media, to a scientifically illiterate general public. Scientific facts are the key components to public understanding of science under the deficit model—a model widely criticized by science communication scholars (for example, see Wynne, 1992; Durant, 1993; Gross, 1994; Gregory and Miller, 1998). However, as indicated by the focus of NSF's biannual *Science & Engineering Indicators* on scientific literacy, the deficit model still enjoys favor among scientists and scientific organizations. The scientific community's concern about the "accuracy" of scientific representations in visually based fiction also demonstrates a reliance on the deficit model. In fact, one of the main reasons scientists consult on fictional productions is to ensure as much "accurate" science gets into the texts as possible. If a scientist believes that "inaccurate" scientific depictions in fiction are eroding the public understanding of science, then, the reasoning goes, "accurate" science in fiction should increase scientific literacy and public understanding of science. However, the scientific community's concern for "accuracy" in fiction is misplaced, and an application of the deficit model to fiction will not result in greater public understanding of science.

One of the first problems with applying the deficit model to fiction is the model's reliance on a conviction that audiences will be able to judge the difference between "good" science and "bad" science in fictional texts. Previously I have shown how the construction of fictional films "naturalizes" the images and depictions embedded within their narratives (Kirby, 2003). Filmmakers construct fictional films so that the film's content appears to be natural and normal and, therefore, appears to be perceptually "realistic." The representation of natural phenomena, scientists, and research spaces, whether they represent "good science" or not, are all rendered "realistic" within the filmic framework, making it difficult for the public to separate fact from fiction. The "naturalizing" effect of visually based fictional media is one reason why scientists believe that fiction negatively affects the public understanding of science. "Scientific knowledge" emanating from fictional films is as, and probably more, likely to represent "bad" science as it is to be "good" science. This is why organizations such as the NSF are worried about the inclusion of "scientific bloopers" in films and the increase in the number of shows featuring pseudoscience; under the deficit model, flawed fictional science will harm scientific literacy and, thus, will hurt the public understanding of science.

As discussed in this article, the presence of scientists certainly increases the chances that a film will contain a higher percentage of "accurate" science. Although science advisers can increase the amount of "accurate" science, they are not able to render all the scientific depictions "accurate." There is still no way for audiences to know which depictions are "accurate" and which result from filmmakers' creative license, because all the representations are projected as "natural" through the camera lens. Filmmakers add to the confusion by using scientists in their publicity material. By claiming scientific legitimacy for their films

through the use of science advisers, filmmakers add to the "naturalizing" effect. They lead audiences into thinking that their scientific representations are not only "plausible" but that they match up with the natural world.

Another factor to examine when placing fictional science in the deficit model is the notion of "accuracy" itself. Although consultants can help filmmakers to portray more "accurate" science, this is not the same thing as creating scientific representations that correspond to the "real" natural world. Dustin Hoffman and Helen Hunt's concern for accurately portraying real scientists raises the interesting question of what, in fact, would be considered an "accurate" portrayal of a "real" scientist. It is as if these actors are looking for some specific, but generalized, behaviors in the actions of a "scientist" that would help them to convey to audiences that they are indeed viewing a realistic scientist. Did Hoffman's intensive watching of Donald Francis provide him with some insight that allowed him to portray the "reality" of a scientist? Did Hoffman and Hunt find something unique about scientists and their motivations that would connote "scientist" to the audience versus "stockbroker" or "waitress?" Essentially, audiences are seeing a particular actor's interpretation of "scientist" with modifications to make them heroic or evil, whatever the case may be.

As with depictions of "accurate" scientists, the "accuracy" of research spaces in films is also a problematic area. For example, we can ask the question of how "accurate" was the sonoluminescence laboratory depicted in *Chain Reaction*. The set designers spent hours talking with sonoluminescence researcher Ken Suslick; they thoroughly examined and recorded his laboratory setups, and Suslick even donated laboratory equipment for the sets. Similarly, the help of technician Ron Rogge in designing *Jurassic Park*'s molecular biology laboratory should have rendered it as "accurate" as if the audience had stepped into a typical laboratory on UCLA's campus. The level of interaction between filmmakers and scientists should have guaranteed that each lab was completely "accurate," and that the public should have had some insight into "real" scientific workspaces. This, however, was not the case. For *Chain Reaction*, the equipment Suslick donated was old, outmoded, and useless at the time of the filming (Reese, 1997). Likewise, the laboratory in *Jurassic Park* was far from a typical molecular biology laboratory. According to Rogge, he "always tried to pick equipment which was the most expensive, that looked the nicest," picking a specific microscope because it "was a lavish, expensive, top-of-the-line scope" (see Mestel, 1995: 29). In each case, the films lead the audience to believe they are looking at "accurate" representations, but in one case the laboratory is 10 years out of date and in the other it is a molecular biology laboratory few scientific institutions could afford. Finally, my research on the portrayal of disputed science demonstrates that even when filmmakers adhere to the advice of their consultants, what is shown in the film may not actually correspond to "scientific fact." In these cases, "accuracy" is in the eye of the beholder.

While increasing "scientific accuracy" in fiction may not enhance the public understanding of science as proscribed by the deficit model, the presence of scientists in the filmmaking process can improve the public understanding of science; that is, if we take scientists' concern with "public understanding of science" to mean more than public "appreciation" of science. George Gerbner's empirical studies demonstrate that frequent viewing of visual fiction correlates with negative attitudes toward science and scientists. However, this negative impact on public attitudes has little to do with the "accuracy" of the scientific representations. Rather, it is a function of the context and tone in which scientific content is presented. A fictional text is likely to negatively affect public attitudes toward science if scientists are depicted as "mad or bad," science is presented as "dangerous," or laboratories express a sense of secrecy. Science consultants can contribute to the dismantling

of these elements without the need for scientific "accuracy." The presence of science consultants on a film minimally prevents the depiction of scientists as one-dimensional stereotypes. For example, the script consultants for *Deep Impact* complained to the filmmakers about the inclusion of an eccentric astronomer who ran around nude at an observatory. According to consultant Chris Luchini, the nude astronomer was "thrown out immediately" after scientists objected (see Yam, 1998). Like Luchini, most science consultants balk at depictions they feel will convey to the audience the problematic stereotypes of scientists as "mad" or as "absent-minded professors." Likewise, the presence of a scientist can help ensure that research spaces do not resemble the gothic, dungeon laboratories in old horror films or any other caricatures. Consultants can also help filmmakers craft images and narratives that convey the "excitement" of scientific research or communicate a sense of "awe" about the natural world. Whether the surface of Mars matches the "real" Mars or not does not matter if the film is able to inspire people about the possibility of Mars exploration. While scientific "accuracy" in fiction may not increase public understanding of science, that is not to say that science consultants do not have a place in the filmmaking process. Scientists can still add to the plausibility of a story and contribute to an audience's enjoyment of a fictional text, without being hog-tied by the notion of "accuracy."

Notes

1 Although other forms, such as comic books, graphic novels, and video games fit into the categorization "visually based fictional media," my reference will always be to fictional films and television shows.
2 Steve Goldman has also done a survey of images and representations of technology in fictional films (see Goldman, 1989).
3 Although a significant number of films prior to 1980 utilized science consultants, there has been an increased willingness of the scientific community to act as entertainment industry consultants throughout the last decade. In a previous study of science consultants, I identified 101 films that had utilized a science consultant. Of those 101 films, 36% of them were in the time period between 1990 and 2001, with all other decades having between 7 and 11% (see Kirby, 2003).
4 Other consulting companies include Sci-Med, Tech Props, and Advanced Scientific Knowledge.
5 The film was released in the US under the title *Rocket to the Moon* in 1931.
6 Unsurprisingly, these new investors turned out to be the Wehrmacht, the German Army.
7 The material in this paragraph pertaining to Matthew Golombek comes from Matthew Golombek, interview by David Kirby, Jet Propulsion Laboratory, 11 June, 2002.
8 Although some observers believe this topic has been explored in the past, a comprehensive literature search revealed only the following works: Yandetti, 1978; Reingold, 1985; Turow, 1989; Mitman, 1999.
9 In the theoretical framework of "multiple authorship theory," the fact that filmmakers turn to science advisers for specific advice and consultation means that scientists can be viewed as one of the "authors" of a film. For discussions of multiple authorship theory, see Gaut (1997), Livingston (1997), Hoppenstand (1998), and Naremore (1999: 22). See Kirby (2003) for a discussion of science consultants' level of control over the depiction of science in fictional films.
10 For example, science consultants worked with actors on *Mimic* (1997), *The Relic* (1997), and *Deep Blue Sea* (1999).
11 Boyles's "nameless technicians" did not receive any credit for running his pumps. Shapin (1989) argues that the term still applies to lab situations today. See also Barley (1994).

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