CHALLENGING IMPLICIT GENDER BIAS IN SCIENCE: POSITIVE REPRESENTATIONS OF FEMALE SCIENTISTS IN FICTION

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***Abstract**: Despite decades of research and affirmative action, women continue to be under-represented in the sciences. Cultural assumptions and stereotypes are a key factor impacting women's entry into and retention in the sciences, indicating the need for improved role models for girls in science education. This paper reviews the critical research on Media representations of female scientists, and argues that more positive role models are found in fiction. This research examines the kind of cultural work such representations might perform, analysing a diverse sample of texts from 1905 to the present. These images of female scientists provide numerous examples of positive, non-traditional role models, examples of egalitarian scientific cultures, and critiques of contemporary science. Informed by this analysis, the article considers how these representations might be used to challenge stereotypical assumptions concerning women's role in the sciences.*

***Key-words:** Gender, science education, female scientists, representation, role models*

For more than three decades, researchers and scientists have debated the "women in science" issue. Despite improvements in their position, the status of women in the sciences continues to provoke concern, as women remain underrepresented in most areas of science, have low rates of retention and are less likely to reach the higher echelons of research and academic positions.

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I. Representations of women in science

As the 2006 report from the U.S. National Academy of Sciences noted, 'Neither our academic institutions nor our nation can afford such underuse of precious human capital in science and engineering' (NAS, 2006, 1).While these trends are mirrored in most of Western Europe (and other countries such as Australia), The Unesco Science Report 2010 shows that despite their pre-eminence in terms of research output and expenditure, the U.S. and Western Europe are outperformed by other countries in terms of gender equity (Schneegans, 2010). Women form close to 50% of science researchers in a number of countries in Latin America, Eastern Europe and Southern Asia.[1] In contrast, while US women's share of undergraduate degrees has soared in some areas, across most of the sciences women are less likely to continue on to advanced degrees or scientific careers. A 2011 National Science Foundation report shows that while women in the US now account for well over half of undergraduate degrees in areas such as biological sciences (59.8%) and medical science (84.5), they remain a minority in areas such as Engineering (18.5%) and Computer sciences (17.7% – down from 28% in 2000). Further, while women's share of graduate studies has improved in the last few years, these figures don't flow onto senior academic and career positions.[2] Women's share of S&E occupations is roughly half that of their participation in the general workforce, with a much lower percentage of jobs in professions such as Physical scientists (32%), Math/computer scientists (25%), and Engineers (11%) (NSF, 2011). So why do US women continue to fall foul of the "leaky pipeline"?

The example of countries which have achieved gender parity suggest that it is not lack of interest that keeps women out of science, but rather a complex mix of social, cultural, economic and political factors. The extensive body of research into the women in science question has documented numerous factors which impact on women's ability and desire to follow a career in science (Eisenhart & Finkel, 1998; Lederman & Bartsch, 2001; Rosser, 2004; NAS, 2006). A central concern are the factors influencing girls' early education choices, and how these are shaped by gender schemas, cultural stereotypes, and peer influence (NSF, 2003; Stake & Nickens, 2005; Dweck, 2007; Halpern, 2007; Hines, 2007). The 2006 NAS report,

[1] For example, EU countries with leading % of women researchers are: Lithuania (49%), Latvia (47%), Bulgaria (45%); in Cuba 53% of all S&T professionals are women (Schneegans, 2010)

[2] The 2008 NSF report showed that women's share in postdoctoral fellowships showed a drop off in all fields, with a high of 40.41 % in biological sciences, and lows of 17.51% in both engineering and computer sciences and 20.21% in physical sciences (NSF, 2006-2008: G1). In terms of academic employment, the 2008 report found male doctoral faculty "outnumber female S&E faculty by more than 2 to 1" with the discrepancy even more pronounced in prestige institutions: only 29.5% of S&E faculty at first-ranked research universities are women (NSF, 2006-2008, H5). These figures included social sciences, thus the proportion of women in other science areas may have been even lower.

Beyond Bias and Barriers confirms that the existence of 'implicit biases' continues to play a central role in women's under-representation in Science and Engineering (NAS, 2006, 3). In other words, there are persistent stereotypes about girls and science that infuse popular culture, education, peer and family influence (resulting in the phenomenon known as "stereotype threat").[1] These are cultural, rather than structural issues and are thus difficult to identify and address directly through affirmative action and compensatory educational strategies.

A significant body of literature stresses the need for more positive role models as a way of countering such implicit bias (LaFollette, 1988; Schmidt & Nixon, 1996; Flicker, 2003; Steinke, 1997, 1998, 1999, 2005). Media role models have seen a marked improvement in the last few decades, with capable female scientists becoming more common in both film and television, yet many of these images are compromised by their continued reliance on stereotypes of normative femininity. A number of science communication studies consider the impact of such media images on girls' perception of science. Film is identified as a key source because 'images of scientist are more likely to appear in popular films than in the other media used by [adolescent girls]' (Steinke 2005, 30). However there has been little research focussing on the representation of female scientists in other forms such as literature. Yet fiction, and in particular the genre of science fiction (SF) is more likely to provide non-stereotypical images of female scientists. Unlike media such as Hollywood films where, as Steinke notes, there persists both "overt and subtle stereotyping of female scientists and engineers", SF literature offers a much greater range of positive, non-stereotypical and even feminist depictions of women in science (Steinke, 2005, 55; see also Flicker, 2003).

This article considers what science-fictional images of female scientists might contribute to the debates about women in science. First reviewing the literature from science communication on images of female scientists, I turn to consider the alternatives offered by SF. Based on analysis of a broad sample of SF texts from 1905-2010 the article explores how these representations both respond to, and interrogate, existing cultural mores, and the changing attitude to women's education in the sciences. Finally, the article concludes by examining the role such fiction may play in the efforts to make science more attractive to women and girls.

Comparing Media and Literature Representations

Media SF has been identified by researchers in science communication and education as a forum that highlights and reinforces certain cultural and popular

[1] Stereotype threat refers to the negative impact on girl's performance when stereotypes about innate abilities are reinforced — for example, girls will not perform as well on tests when told boys are better than girls at math, but perform better when told both are equally as good at math.

understandings of science. Particularly given a persistent concern over how scientists and their activities are stereotypically represented, a great deal of attention has been given to media images, including fictional representations in film and television. SF *literature*, however, has been undervalued as a resource for science studies and the public communication of science. Yet as some critics have noted, SF provides a unique source for considerations of the socio-cultural relations and discourses of the sciences (Haraway, 1989; Rose, 1994; Willis, 2006). Beyond the stereotypical "space operas' and media blockbusters, the genre has produced many serious considerations of the impact of science and technology, with the relation of gender to science an ongoing theme since the genre's beginnings in the pulp magazines of the 1920s. Like science studies, SF is fascinated with science but importantly its engagement is played out in a public and popular domain (Grebowicz, 2007, xvi). The value of SF lies not in its predictive capabilities, or potential to cushion "future shock", but its function as a thought experiment or "dream laboratory" (Rose, 1994, 228), which reflects social hopes and fears about scientific and technological developments. As author Nancy Kress observes, "In the world's laboratories, science rehearses advances in theory and application. In Fiction, SF writers rehearse the human implications of those advances" (Kress, 2007, 207). While there has been little work to date specifically on scientists in SF, other studies have utilised the genre to explore science related themes, including the use of SF texts in science education (Berne & Schummer, 2005), sustainability education (Gough, 1993, 2005); the intersections of nanotechnology and SF (Milburn, 2002); and the representation of science and technology in comics (Locke, 2005).

Literary vs. media SF

Two important distinctions need to be made between literary and media versions of SF in considering how the genre might reflect, reinforce or intervene in popular understandings of science. Firstly, written SF is less constrained by the cultural and economic imperatives of the mass market. Being individually authored, much cheaper to produce, aimed at narrower, specialist audiences, with numerous publications venues (from specialist and trade presses to short fiction markets) SF literature has more freedom to critique and depart from the norm. Thus in SF books we are likely to find a greater diversity of ideas and more complex representations of both science and scientists. Additionally, unlike the majority of film or television scriptwriters and producers, a number of SF writers are scientists (or have science qualifications).[1]

[1] See, for example, the SIGMA organisation: "a non-profit organization dedicated to improving the understanding of the future and the long-term consequences of government actions" comprised mainly of SF writers who also have PhDs in Science and engineering http://www.sigmaforum.org/members.php

There are also significantly more women (and feminist) writers, editors and publishers of SF than female screenwriters or film producers.[1]

Balanced against the relative constraints on media representations is the greater scope for potential influence in terms of audience reception. Media texts are seen as the pre-eminent vehicle for reproducing and reinforcing cultural models in contemporary society. Undoubtedly, claims about impact on public perception are more easily made for blockbuster SF movies than for SF novels, which have a much more limited audience. As many researchers have noted, popular media engagements with science through SF film, for example, can have a significant impact on the public perception of certain issues, debates, and importantly, conceptions of scientists (Griffin, Sen, & Plotkin, 1994; Flicker, 2003; Lowe et al., 2006; Steinke, 2005, 1998). In particular, media is viewed as a crucial shaper of children's and adolescents' perceptions of science, due to its mass appeal, young people's increasing media literacy, and the amount of leisure time spent viewing media such as television and games (Steinke 2005).

Despite the broad appeal of media for young audiences, written texts still have an important role to play, not least in education, ensuring that reading remains an important facet of young people's lives (even if enforced, rather than chosen). When our concern is with the socialisation of girls in particular, then reading may be an even more important consideration, as research suggests that girls continue to be more frequent and stronger readers than boys (Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006, 271). Research by Ford et al (2006) focuses on the function of written texts in science education experiences for girls. As they argue, it is important to consider the role of fictional texts as "socialising agents", particularly as girls are shown to be less likely to read non-fiction texts such as science books. While Ford et al consider a range of fictional and non-fictional genres which touch on science, including 'animal' books and fantasy, they do not specifically consider SF. However other studies have noted the role that SF books might play in school science curricula (Weaver & Black, 1965; Gross & Woodburn, 1959; Berne & Schummer, 2005).

Cultural images of scientists

The issue of how scientists are represented in the mass media has occupied many science communication researchers, with attention increasingly turning towards

[1] Female membership of the SFWA (SF and fantasy writers of America) is around 38% (from 2000 and 2007 figures). In a listing of SF&F books forthcoming from U.S. publishers from October 2007- September 2008 (calculated from trade magazine *Locus*), 40% were by women (statistics collated at http://www.broaduniverse.org/stats.html#field). In contrast, women constitute about 27% of TV writers, and less than 19% of film writers; (2007 Hollywood writers report www.wga.org/uploadedFiles/who_we_are/HWR07.pdf).

fictional representations. Indeed, as Peter Weingart and Petra Pansegrau note, it is "plausible to assume that popular images of science and scientists are influenced far more by fictitious characters than by real people" (Weingart & Pansegrau, 2003, 227). However, despite this observation, little research to date has looked at the role of the scientist in literature, perhaps because "(l)iterary fiction has seldom been seriously considered as a mode of science communication" (Russell, 2007, 205). Consequently few studies have examined SF literature for its impact on cultural images of scientists. Even in the emergent area of literature and science studies, the focus is on canonical literature, and most often on nineteenth century texts (including almost an entire subgenre of studies on *Frankenstein* alone) (Russell, 2007; Willis, 2006). This lack is also evident in the specialist discipline of SF studies, where, as Willis argues, "extended readings of the use of science in SF texts is extremely rare" (2006, 1).[1]

One of the few studies in this area is Roslynn Haynes' survey of the scientist in western literature, which identified a number of stereotypes such as "the mad, bad, dangerous scientist", and found that representations of "good scientists" were in a minority (Haynes, 1994, 2003). While including a number of SF texts, Haynes' overview does not extend to a broad sample of the genre, which in part impacts her conclusions about the scarcity of positive images of scientists. One of the very rare studies to focus specifically on SF provides quite a different picture. In 1958 William Hirsch conducted a content analysis of SF, which found that the image of scientists had improved since the 1920s and '30s, moving towards more realistic depictions of scientists as "real human beings" rather than "supermen or stereotyped villains" (Hirsch, 1958, 512).[2]

The area of fictional film and television, in contrast, has been the subject of a growing number of studies, particularly in science communication (Vieth, 2001; Weingart, Muhl, & Pansegrau, 2003; Frayling, 2006; Terzian & Grunzke, 2007; R. Jones, 2001). Not surprisingly, SF is an important focus in these works, for as Flicker notes, it is "the genre that most often thematizes science" and is thus most likely to feature scientists (Flicker, 2003, 310).

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[1] Other critics such as Roger Luckhurst have argued for the need for scholars of SF to situate the genre within broader disciplinary contexts including studies of science and technology (Luckhurst, 2005: 3).

[2] More recently, Jennifer Rohn has written about a new genre she terms 'lab lit', referring to "novels containing realistic depictions of scientists plying their trade" (Rohn, 2006). Rohn's online magazine designed to promote includes a separate section on SF, even whilst many SF authors appear in the main list: see http://www.lablit.com/the_list

II. Media images of female scientists

There are a number of studies focussing specifically on representations of women scientists, ranging from their depictions in journalism (LaFollette, 1988; Shachar, 2000), to science books (McArthur, 1998), television (Steinke, 1998), and film (Steinke, 1999, 2005; Elena, 1997; Flicker, 2003; Noonan, 2005). These studies (and those on images of scientists generally) fall into two distinct groupings, distinguished by their disciplinary approach. One focuses more on the range of *cultural meanings* represented by such texts, and the ways in which they both reflect and intervene in cultural understandings of science. These studies are generally cultural or literary studies, or emerge from the interdisciplinary area of science and literature studies (Noonan, 2005; Squier, 1999; Russell, 2007; Willis, 2006).

The other approach, issuing from science communication and education, is often primarily concerned with the ways in which images of scientists might function as *cultural role models*. Such studies proceed from the understanding that there are significant links between popular perceptions of scientists and media representations (Chaloner, 1999, 259; see also Flicker, 2003). In those studies looking at images of female scientists, a key assumption is that improvements in media representations will have measurable effects on the entry of women into science. As Steinke, for example, argues, "[p]ortrayals of female scientists and engineers that show women as realistic professionals in prestigious positions may provide adolescent girls with positive role models" (Steinke, 2005, 53). The differing perspectives and modes of analysis offered by these approaches both provide important contexts for my investigation of female scientists in SF, in particular the work of Noonan and Steinke.

Gender, science and 1950s films

In *Women Scientists in Fifties SF films*, Noonan – an English Professor – focuses on representations of female scientists in these iconic "B" grade films. Perhaps surprisingly, given the subject matter, Noonan's analysis suggest these films present quite radical challenges to the stereotypes of women and science that were current at the time. A similar argument is provided by Errol Veith, who offers an even more positive reading of the "liberation" afforded these female characters through their access and exposure to scientific knowledge and education (Vieth, 2001). Informed by feminist theory, Noonan's analysis is a more cautious and complex reading of societal fears about changing gender roles, in particular the conflict between women's traditional family-orientated roles, and emerging professional opportunities. The figures of the women scientists in these films clearly demonstrate "the tensions inherent in attempting to represent gender equality without challenging patriarchal norms" (2005, 59).

Nevertheless, Noonan argues that these fifties films offer potentially liberating visions of women's engagement with science. A number of the films she discusses represent women as "full-fledged scientists", including: Dr Lisa Van Horne, (chemistry, fuel engineer) in *Rocketship X-M* (1950); Dr Patricia 'Pat' Medford (entomologist) in *Them* (1954); Dr Lesley Joyce (marine biologist) in *It Came From Beneath the Sea* (1955); Dr Ruth Adams (nuclear Physicist) in *This Island Earth* (1955); and Dr Diana Fairfax (medical science foundation administrator) in *"X" The Man with the X-Ray Eyes* (1963). [1] The range of scientific specialties represented in this list it itself suggests a significant departure from the usual 1950's stereotypes of women. Films such as *It Came from Beneath the Sea* (1955) were, Noonan argues, radical for their time in their extrapolation of "a socially acceptable representation of a successful woman scientist" (2005, 69). Noonan acknowledges that this film was somewhat atypical in presenting a professional woman whose sexuality was not contained by being subject to a male authority figure, such as a father figure or lover. In other films, the tensions arising from gendered relations are more traditionally resolved by ending in catastrophe, as in *Rocketship X-M* (1950), with the death of the female scientist (62).

As Noonan emphasises, the scientific capabilities of these women scientists must be moderated by physical attractiveness – a factor that is still present in much later films (Steinke, 2005). Interestingly, Noonan sees this image of women as "both professionally successful and sexually attractive" as a positive feature, given the constraints of fifties gendered schemas (53). However, the connection between sexual attractiveness and scientific success has by the 1980s and 1990s, become another restrictive stereotype that tends to detract from, rather than enhance, the believability of the fictional female scientist.

Noonan also makes some important points about equality that have implications for the notion of role modelling. In these fifties films (as in later movies) it would appear that merely having a capable woman accepted as an equal part of a scientific team is an important and positive development. However, such gestures towards equal opportunity do not necessarily advance a better, or more accurate, understanding of gender and science, as they tend to reinforce what Noonan calls the 'hypothesis of the genderless nature of science' (56). Drawing on feminist science theorist, Evelyn Fox Keller, Noonan argues that: "such an elision of gender difference presupposes a relationship between 'humans and science' as opposed to 'men's and women's relations to the pursuit of science', a relationship that thus perpetuates existing social inequalities" (Noonan, 2005, 54; Keller, 1991, 226-7). That is, a straightforward representation of men and women working equally in science (which does not

[1] Other characters include science students such as Lori Nelson (ichthyology graduate student) in *Revenge of the Creature* (1955) and Stephanie "Steve" Clayton (biology graduate student) in *Tarantula* (1955).

acknowledge the various cultural and structural difficulties or barriers faced by women) presupposes an environment of "gender neutrality" which may be detrimental to efforts to improve women's participation in the sciences (see also Eisenhart & Finkel, 1998, 179-206).

Contemporary female scientists in film and TV

Jocelyn Steinke has conducted a number of important studies on the impact of media on girls' and women's relation to science (Steinke, 2005, 1997, 2004, 1998, 1999; Steinke et al, 2012). Much of her research is concerned with the effects of media representations on the "gender-stereotyped perceptions of science and engineering as masculine careers" (Steinke, 2005, 35). Media images of female scientists and engineers are, Steinke believes, "important for advancing our understanding of the gender schemas that serve as potential sources of influence during a particularly impressionable time in the lives of adolescent girls" (2005, 36). Studies show that girls' interest in science begins to decrease from about twelve years of age (Steinke, 2005, 29), "the same age at which many girls show a heightened awareness of gender roles" (30).

Steinke's 2005 study considers female scientists in 23 films from 1991-2001.[1] Steinke analyses the fictional female scientist in terms of five key representational themes: 'appearance; characterization; expertise, ability, and authority; work versus romance; and work and family life balance' (Steinke, 2005, 38). In terms of characterisation and appearance, Steinke found that all characters were (eventually) depicted as attractive, if not glamorous (39); eighteen were characterised as 'professional' with a few as "mad" and "clumsy" and one as "nerdy and antisocial" (42). Nearly all the scientists and engineers were depicted as being of a high professional status, with eleven being directors, two administrators, nine equal members of research teams, and only one an assistant (44). Twenty out of the twenty three characters were shown as being involved in romantic relationships, but in only four of the films were the women also mothers (50, 52).

Steinke concludes that although gendered representations have improved, "stereotypical images of women still are found in the mass media today" (2005, 53). However, despite the trappings of femininity that remained key to these representations (beauty, romance etc.) Steinke notes that the films "did not necessarily, in all cases, urge conformity to traditional stereotypes of women" (53). That is, while physical

[1] This sample was drawn from a broader pool of popular films featuring scientists as major characters; the films comprised a mix of genres including: action/adventure, comedy, drama, science fiction, and horror.

attractiveness and the presence of romance were important, most of the female scientists were:

> shown in positions of high prestige, such as project directors or equal members of research teams, and were knowledgeable, articulate, outspoken, driven, confident, competent, creative, and independent, even when romance was a dominant theme (53).

Indeed, the very juxtaposition of realistic, competent portrayals with the more traditional feminine trappings of beauty and romance may, according to Steinke, be a positive factor, allowing for "better identification" by young female viewers (53). However, as Steinke also notes, a crucial factor mitigating against these portrayals was the lack of balance in work and family life depicted in the films. As many researchers suggest, a significant factor in women's under-representation in the sciences is the difficulty of combining scientific academic careers with motherhood and family care (Steinke, 2005; see also Hanson, 2000).

Steinke concludes that "[m]ore research is needed to examine the features of these media portrayals of female scientists and engineers that most appeal to girls and to determine which portrayals, if any, are most effective in changing girl's attitudes toward SET careers" (2005, 55). However, given the limitations of these media portrayals, I argue that such examinations could also be extended to areas where we are more likely to find non-stereotypical portrayals – in written science fiction.

III. The female scientist in Science Fiction

Writing in the late 1990s, SF critic Jane Donawerth observed that '[a]lthough SF by men generally lacks women scientists, women writers have regularly pictured women as scientists' (Donawerth, 1997, 4; Rose, 1994, 215). Thus, the likeliest source of positive images of female scientists in SF is the growing body of women's and feminist SF which emerged most visibly from the 1960s onwards.[1] The burgeoning of women writers and readers in the field during this period coincided (and was invigorated by) the women's liberation movement, which included significantly increased opportunities for women in science and engineering education and careers. The last couple of decades have seen a shift, as an increasing number of male SF writers have written about female scientists.

The following analysis is based on an initial sample of SF texts featuring female scientists, sourced from my previous research on women in SF (Merrick, 2007, 2009); Donawerth's work (1990; 1994; 1997), online subject bibliographies, online

[1] Key studies of women's and feminist SF include Lefanu (1988) and Wolmark (1993).

databases and Encyclopaedias.[1] The texts range in publication dates from 1905 to 2012, featuring 106 examples of female scientists of which 94 are the protagonist or a major character. This selection of texts is not intended as an exhaustive or representative survey, but rather a preliminary sampling that serves to indicate a range of possible representations. Given these limitations, some trends do seem significant and worthy of further attention. Firstly the gender balance seems to bear out Donawerth's earlier observation, with 42 authors being male and 64 female. The range of scientific professions represented for the most part mirrors real world trends, with the largest category of characters shown as working in the biological (31) and medical sciences (12), compared to much lower numbers in computing (9) agricultural sciences (2) chemical sciences (3) earth sciences (4) engineering (6) and maths (5).[2] A surprising number of the characters are physicists, with 17 in all (although interestingly only five of these characters were written by women). The sample also demonstrates that positive images of female scientists are not just confined to the post-war era, but in fact reflect the much longer history over the struggle for women's place in the sciences.

Historical contexts

It is important to note that the history of women's campaigns to enter the sciences has been reflected in popular texts throughout the last century. Images of female scientists can be found in a number of nineteenth-century female utopias, coterminous with the first wave of women's rights and suffrage movements. Texts such as Mary Bradley Lane's *Mizora* (Lane, 1881) and Charlotte Perkin Gilman's *Herland* (Gilman, 1915) feature imagined societies where women hold important roles in scientific research and education.[3] Somewhat later, my sample shows a group of SF texts from the 1920s and '30s depicting women as scientists and engineers, such as "The Menace of Mars" and "The Ape Cycle" by Clare Winger Harris (1928; 1930), and Louise Rice and Tonjoroff-Roberts' "The Astounding Enemy" (1930). There are obvious links between these stories and the earlier feminist utopian writings that emerged in the context of late nineteenth-century

[1] Online sources included: Jennifer Rohn's Lablit site http://www.lablit.com/the_list; SF author Alison Sinclair's site http://www.alisonsinclair.ca/reading-writing/women-scientists-in-fiction/; Laura Quilter's Feminist Science Fiction, Fantasy and Utopia site http://feministsf.org/. The site also allowed visitors to suggest examples through an email form. The database is available at https://projects.ivec.org/womeninscience/

[2] Seventeen of the characters' field of science is classified as 'other' – which includes archaeology, linguistics, or invented or non-specified sciences.

[3] Another interesting example from outside the Anglo-American tradition is a scientific utopia written by a Bengali woman, Rokeya Sakhawat Hossain, in 1905, 'Sultana's Dream'.

campaigns to gain science education for women. As Donawerth argues, 'Women scientists as characters in women's SF are thus a legacy of the earlier feminist utopias, which represented the dreams of women for education in the sciences' (1997, 5). There is something of a hiatus during the war years, (with only one example from the 1940s, Miriam Allen deFord's "The Last Generation" (1946)) followed by another cluster of texts in the 1950s. This period also marked a time of increased interest in science education generally, although critics argue that overall the post-war reinforcement of domesticity was detrimental to women's opportunities in science (Schiebinger, 2001; Rossiter, 1995; Watts, 2007).

A number of examples from this period were by male authors, with the most (in)famous science-fictional female scientist, Dr Susan Calvin, appearing in Isaac Asimov's story, "I Robot" (Asimov, 1950). The image of Calvin is marred for contemporary readers by the conflict between her role as scientist and the trappings of traditional femininity. In order to maintain her scientific identity, Calvin's "feminine" qualities are ossified – she is depicted as a repressed, unfeminine, spinster who looks to her own artificial creations for affection. More interesting and complex representations are found in John Wyndham's 'Consider her ways' (Wyndham, 1961) which shows an alternate female-only 'hive-like' world where many women are scientists; and Philip Wylie's *The Disappearance* (Wylie, 1951) where both sexes effectively 'disappear' as far as the other is concerned, and women are shown performing all the roles left vacant by the men. Katherine MacLean also published a number of stories from the 1950s which routinely featured female scientists working capably alongside their male counterparts including "And be Merry…" and "Contagion" (1950a, 1950b). The early 1960s brought two very different but significant texts featuring female scientists. In *Memoirs of a Spacewoman* (1962) British writer Naomi Mitchison imagines a future where science is full of women (including women of colour) who partake equally in scientific research and alien expeditions to other worlds. The imagined society of *Memoirs* displays radically altered attitudes to motherhood, childcare and partnering, resulting in an environment where women routinely take on the roles of both scientist and mother. The children's book *A Wrinkle in Time* by Madeleine L'Engle (1962) also features a scientist mother, who does her lab work at home so she can continue to look after her children.

Women's and feminist SF

From the late 1960s onwards, the growing body of work by feminist authors in SF, along with a broadening of the genre's themes and concerns, produced many images of female scientists. Even texts which did not directly represent scientists were often engaged in explorations and re-imaginings of the sorts of cultural, political and economic institutions that contextualise and underpin contemporary science,

with obvious consequences for women's potential to engage in, and with, the sciences. Examples include the group of feminist utopian SF texts that for many critics later come to codify the intersection of feminism and SF writing in the late 1960 and early '70s (Russ, 1981; Lefanu, 1988; Barr, 1987). While few of these texts are centrally focussed on female scientists as such, many of them imagine transformed societies where the practice of science and role of the scientist have been radically changed. Female scientists are an accepted part of the society of Annares in Ursula Le Guin's *The Dispossessed* (1974), although they do not figure as central characters. In texts such as Joanna Russ' "When it Changed" (1972) and *The Female Man* (1975), or Marge Piercy's *Women on the Edge of Time* (1976) we see cultures where understandings of work, education, technology and knowledge have been so re-imagined that one almost overlooks the scientific work carried out by women as a routine part of everyday life. In quite a different example, the post-apocalyptic, tribe-like society of the Riding Women in Suzy McKee Charnas' *Motherlines* (1978), appear to possess no advanced science or technology. However their very existence and continued reproduction has been made possible by their female ancestor's experiments with cloning and parthenogenesis.

IV. Contemporary images of female scientists

As women authors, female characters and feminist themes have become more common in the SF field, representations of female scientists have become more numerous and varied. These images of women in science may function not only as non-traditional, positive role models, but more complexly as a way of thinking through the cultural and political contexts which impact on women's relation to the sciences. In some cases, texts which contain critical or negative portrayals of women's struggles as scientists may be as powerful as positive role models in thinking through the "women in science problem". Further, texts which present an egalitarian vision of science, while offering positive images on the surface, may not be as useful as they first appear.

Critiques of science as usual

Many women-authored and feminist SF texts offer explicit critiques of the practice of contemporary western sciences, some through envisioning radical alternatives, and some by emphasising the problems faced by working female scientists. A short story by the East German writer, Christa Wolf, offers an intriguing, early consideration of the intersections of science, gender and sex. First published in 1973, her "Self Experiment. Treatise on a Report" concerns the involvement of a female scientist, Anders, in a sex-change experiment, which successfully turns her into a man (Wolf, 1973). Unusual both for its mimetic representation of a female scientist at work, and

its interrogation of scientific practice and language, the story takes the form of a 'treatise' or supplement to the official (and classified) research report on the experiment written by Anders. Wolf's story illuminates the conflicts and contradictions characterising the question of women's place in the sciences; as Friederike Eigler notes: " As the narrator realizes in hindsight, she had to deny her gender in order to be successful as a female scientist. In other words, in order to prove herself as a woman, she had to become (like) a man" (Eigler, 2000, 2)

In "Self Experiment" this "denial of gender" that has often characterised women's struggles to carve out an identity as scientist is made overt as Anders quite literally becomes a man. The notion of a "Female Man" was powerfully utilised by Joanna Russ (in her 1974 novel of the same name) as an ironic figure for critiquing and exposing gender bias in all areas of knowledge including science. In Russ' novel the main character claims 'manhood' for herself in order to articulate the dislocation between gender schemas and women's ability to take on roles and behaviour deemed masculine.

In many ways, women have had to be "female men" in order to successfully function as scientists, a notion that is critiqued in a number of texts dramatising the problems faced by female scientists. A powerful example is Kate Wilhelm's *The Clewiston Test* in which Anne Clewiston, a brilliant medical research scientist falls victim to gendered prejudices and power struggles in her work, social circle and marriage (Wilhelm, 1977). In the beginning of the novel, Clewiston is represented as an admired, well-funded research scientist heading an important project into pain management. As complications arise with the project and her personal life, the issue of her gender is used as an excuse to characterise her behaviour as irrational and dangerous, as the company executives, colleagues and her husband wrest control of her project. Ultimately she is forced to escape by the only means left available to her, by admitting herself to psychiatric care.

More recently, Gwyneth Jones' novel *Life* (2004) provides a contemporary vision of the difficulties of a woman working in science. Reflecting the present-day environment of much improved educational and career prospects for women, the protagonist, Anna Senoz is a bright, single-minded student who chooses to study biology, and seems unaware that her gender should pose any barrier to her continued success. *Life* charts the difficulties Senoz faces in her career, set within a broader critical examination of the institutional, epistemological and methodological operations of modern corporate science. The ingrained sexism still prevalent in many university and research environments is painstakingly drawn, as Senoz faces numerous challenges in both her professional and personal life. From her rape by a fellow graduate student, to her consequent failure to achieve a prestigious graduate placement, her scientific work choices, opportunities for research, publication and peer acknowledgement are shown to be impacted by the fact she is a woman.

Woven through the narrative is also the story of her central scientific discovery (which ultimately brings her infamy) – the Transferred Y (TY) viroid. Extrapolated from real-world research into the "descent" of the Y Chromosome (Aitken & Graves, 2002; Graves, 2002; S. Jones, 2003), TY describes a phenomenon whereby sections of the sex-determining region (SRY) of the Y chromosome are transferring over to the X chromosome, eventually producing men who are effectively XX males. Jones uses this imagined discovery to engage in detailed critiques of the sex-gender system, evolutionary biology, and the language and production of biological knowledge itself. The most important effect of *Life*'s broad-ranged critique of gender and science is the way it focuses on cultural and political contexts, arguing that gendered discrimination is the result of systemic and cultural biases, rather than biological difference or individual failings.

Although Senoz is in many ways an inspirational figure, she is not so much a positive role model as a realistic and thus troubling representation of a woman in science. Nevertheless, texts such as *Life* can be useful in thinking through the factors shown to impact on girl's and women's success in the sciences. Research on girls' performance in science emphasise the detrimental effects arising from cultural assumptions (from media, teachers, parents and peers) that designate or stereotype a particular group as unsuited to science (Hines, 2007; Hyde, 2007, 138) The complex rendering of Senoz's experiences works to break down such stereotypes, as we are encouraged to read the causes of her marginalisation as arising from cultural and institutional forces, rather than individual failings. Thus, even less-than positive representations of female scientists may provide powerful correctives to the notion that women *as a group* are inherently unsuited to science.

Equal playing fields – visions of gender-neutral science

A different way of countering stereotype threat is of course the portrayal of positive role models for women in science. The availability of such role models may improve girl's ability to imagine themselves as scientists, as suggested by research on self-schemas and the "possible self as scientist" (Stake & Nickens, 2005, 2-3; Lips, 1995). Over the last decade in particular, many SF texts have presented societies featuring male and female scientists and engineers in equal roles. Here female scientists are taken for granted, hold positions of authority, are shown capably doing their job, and enjoying the research they do.

A number of such texts are set in the future, allowing for a shift in the cultures of science such that women are shown as equal participants, in sciences that have become effectively "gender neutral". Sarah Zettel's *The Quiet Invasion* (2000) is set on a scientific research colony on Venus, which is headed by the eighty-year old scientist Dr Helen Fallia. Another key character is Dr Veronica (Vee) Hatch who has

a PhD in planetary atmospherics and works as a holographic artist and science populariser. The society Zettel depicts appears egalitarian in general, with high-powered women in other roles, such as the UN politician Yan Su. Set in a less-distant future is Greg Egan's *Distress* (1995), where women's equal participation in science also seems taken for granted. Here however, other shifts in gendered roles are apparent, most obviously signalled by the cultural phenomenon of "gender migration", which posits seven genders as the norm, including "a-sex" (or neuter). Like Zettel, Mitchison and others, Egan's expanded vision of science is inclusive in terms of race and ethnicity, as well as gender. The central scientist is a Black South African woman, Violet Mosala, who is a Nobel prize-winning quantum physicist. A central theme of the book is the development of a "theory of everything" (TOE), a project in which the work of Mosala and other female scientists (such as Helen Wu) are central. In terms of gender, race and science, the society of *Distress* suggests there is nothing preventing all women from being competitive in science at the highest levels, and in areas such as physics.

Not all gender-equal SF visions are distanced from contemporary relations through a futurist setting. *Darwin's Radio* by Greg Bear (1999), like Jones' *Life*, depicts a near-future much like our present, but in contrast, features a much improved atmosphere for women in science. Numerous female scientists appear in *Darwin's Radio*, which focuses on Dr Kaye Lang, a molecular biologist whose research provides a breakthrough in understanding what appears to be a virus affecting women's fertility. The apparent success of Lang and many other minor female scientists in the book, and asides which praise women's different style of doing science, are undercut by a number of factors. Firstly, the broader system of gender politics remains untouched, with most powerful political and administrative roles occupied by men. In addition, the character of Lang appears to be constrained by many traditional ideas of femininity, including a reliance on partners such as her difficult first husband, and a certain naivety when it comes to any affairs outside her own research. Kim Stanley Robinson's *Forty Signs of Rain* (2004) (and its sequels published in 2005 and 2007) is also near-contemporary, and features numerous female scientists. One of the main characters is Anna Quibbler, a statistician who works fulltime as a senior bureaucrat in the NSF, while her husband takes on the bulk of childcare responsibilities for their two sons. In contrast to *Darwin's Radio*, various factors are evident which support women's work in science – from the Quibbler's domestic arrangements, to the fact that the NSF director is also a woman.

These representations of senior, capable female scientists who are not isolated geniuses obviously contribute to positive images of women in science. However, as Noonan (2005) points out in relation to fifties film, it is problematic to present a gender-neutral ideal of science as a fait accompli (Keller, 1991; Eisenhart & Finkel, 1998). Particularly when coupled with relatively unchanged socio-cultural mores and

gender schemas, these texts beg the question of how such gender-balanced environments emerge. If there have been no significant changes in the ways science is taught, practiced or communicated (and no attendant changes in general societal norms), then the responsibility presumably lies with the individual, not the culture at large. That is, if the only difference between these visions and our society is the number of successful women in science, then the only possible site of change is women themselves.

Gender Equality in science

Given the continuing barriers in real-world scientific cultures, more satisfying representations of gender parity in science occur in stories where there have been obvious shifts in socio-cultural relations and institutions. Such scenarios appear more frequently in texts written by women, which also tend to feature more complexly-drawn female scientists that are more attentive to the interpersonal dynamics and hierarchies which contextualise scientific work.

A recent example is the capable MacKenzie (Mac) Connor, a marine biologist in Julie Czerneda's *Species Imperative* series (2005). Mac could initially be mistaken for a "female man" type, who appears quite tomboyish in her disregard for traditionally feminine attachments to appearance and romance, and her delight in her often demanding outdoor fieldwork studying salmon. However a balance is achieved both through the complexity of Mac's character, and the contrast with her friend Dr Emily Mamani who plays on her femininity and sexuality, whilst being a top rank scientist and expert in her field. This representation of an egalitarian scientific context avoids a simplistic assumption of gender neutrality, due to the ways in which science is conducted and represented in the book. Whilst the plot centres around contact with alien species, the setting in which Mac does most of her research work presents a realistic picture of scientific fieldwork. On Mac's marine research station, graduate and postgraduate students work alongside their professors in a very egalitarian, community-based and gender-balanced environment. They all live and work together, seemingly not hampered by excessive institutional hierarchies and frameworks. Within such a setting, the equal participation of women and men, and the fact that many of the senior researchers and administrators are women appears natural. Furthermore, the characterisation of Mac as a brilliant and committed scientist is leant veracity by the detailed descriptions of her work (helped by the fact that Czerneda herself trained in biology), the discomforts of field research, demonstrations of support from her family, and reminiscences from her childhood that speak of a life-long love of, and fascination for science.

Other examples situate their female scientist in totally re-imagined political and cultural contexts, including Mitchison's *Memoirs* (noted above), and Vonda

McIntyre's *Starfarer* series (1989). McIntyre's scientists work on a space station where scientific research is integrated into daily life, in a future where there have been significant shifts in social institutions such as the family, and where group marriages have become common. As with Greg Egan's work, these texts also represent women of colour as central scientist characters. Overall, these texts evidence a balance of scientific work and family life which Steinke found lacking in her film examples. Indeed, the integration of scientific work into family and community life is a mark of much women's SF, from 1970s utopias such as the female-only world of Russ' 'When it Changed' (1972) to Joan Slonczewski's *A Door into Ocean* (1987). An active researcher in Biology herself, Slonczewski imagines an all-female alien society called the Sharers, who have a radically reformulated vision of biological sciences. An environmental ethics of care and holism is central to their practice, which does not separate work, home or family into different physical or conceptual spaces. Effectively this is a 'domesticated science' where "the person who cleans the labs is very likely the same person who does the science" (Donawerth, 1997, 11).

The visions of women in science depicted in these texts offer a greater range of alternatives and non-traditional images than visual mass media. When compared to Steinke's findings, we see that literature – like film – can offer engaging, realistic depictions of women working in responsible positions, accepted by their peers and enjoying the work they do. However, many more examples from SF literature show *balanced* visions of work and life, with women combining family and children with their scientific work, in non-sexist environments.[1] SF's function as a fictional "social laboratory" means it is freer to experiment with alternative ways of engaging, representing and re-imagining science that are difficult, if not impossible, in mass media. Unlike other media, SF texts are uniquely positioned to interrogate not only the institutional and structural contexts of the sciences, but also its language, theories, practices and methods. In this way, SF fosters an emotive engagement with speculative ideas or images, whether this be nanotechnology, or the depiction of autonomous, respected female scientists as commonplace.

V. Conclusion

This article has argued that SF literature offers alternative avenues for popular engagements with science that may be helpful in identifying (and rectifying) some of the cultural obstacles faced by women entering the sciences. As well as countering factors such as stereotype threat through the provision of positive role models, other

[1] Of the examples discussed above, those scientists who have mothering or childcare responsibilities feature in texts by Mitchison, McIntyre, Bear, Egan, Jones, Robinson, Slonczewski, L'Engle and Bear.

factors identified in the literature may be addressed through recourse to imaginative resources such as SF. For example, research suggests that seeing science and maths ability as a 'gift' disadvantages girls, whereas an understanding of science expertise as the result of work and application may well positively impact on girls' performance (Dweck, 2007, 51-2). Therefore representations of women scientists that can provide compelling, detailed depictions of their work, interactions with others, and the ways their work is balanced with everyday life, offer valuable models. As this article has suggested, there are numerous examples of SF that provide realistic pictures of women doing scientific work and engaged in enjoyable intellectual labour alongside supportive colleagues. Characters like "Mac" from Czerneda's *Survival* and Anna Senoz in Jones' *Life* provide useful antidotes to the notion that successful female scientists must be isolated, rare geniuses. These representations of engaged women who care about their work can also help counter misconceptions of what various scientific careers actually entail, and whether or not they are compatible with more "humanistic" and altruistic values. Such representations may help counter misconceptions of scientific work that may impact on girl's decisions about pursuing science (Eccles, 2007, 209).

While these speculative images of female scientists may not have the popular cachet of Hollywood movies, I argue that they represent an important and under-utilised resource in the effort to improve women's entry into the sciences. More research is needed into the ways in which these role models from SF literature might be harnessed in the ongoing effort to improve the participation of girls and women in science. For, as Steinke argues of film, research into such representations "is critical for identifying specific strategies … to encourage interest in science and engineering careers" (2005, 30). Ultimately, SF literature provides "fantastic" role models for both formal and informal science curricula, as well as representations that interrogate and challenge prevailing cultural understandings of how and why women might participate in science.

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PERSPECTIVES ON GENDER INEQUALITY AND THE BARRIER OF CULTURE ON EDUCATION

Juliet JOSEPH[1]

"Educate a woman you educate a nation"

Former Deputy President
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Abstract: *Education plays an important role in gender equality. Two thirds of illiterate adults are women; this impacts on the lives of families and children because many mothers are the caretakers of the family. This societal challenge might also not be resolved as fast as expected and remains high on the global agenda. It is for this reason that the study will discuss how education can impact on bridging the gender gap. From a young age, many women are taught to be submissive, subordinate and obedient to their male counterparts; and they are less valued than men. This level of consciousness which reinforces cultural norms and expectations ensures the continuous cycle of male patriarchy. Cultural processes maintain gender differences which act as barriers preventing an increase in the education of girls and women and ultimately reducing the number of women in positions of power, thus leading to a small scale of gender equality in a male-dominated society.*

Children spend most of their lives in classrooms and the study presumes that education environments are also the incubation hubs where girls and women can be equally educated and eventually take on their rightful place in society. It has been demonstrated time and again that young girls remain excluded from society, alienated in some cultures because they are female or even unwanted, and can even be murdered because a woman is a liability to her father unlike a male. Education reinforces and conscientises both males and females on social justice, equality; fairness and respect.

Key-words*: Gender inequality; culture; education; inequality; discrimination*

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