REVIEWS

Julia Robinson and Hilbert's Tenth Problem (DVD, 2008). Produced and directed by George Csicsery. Running time: 54 minutes. With 6 additional short features, Zala Films, `http://www.zalafilms.com`.

Reviewed by Margaret A.M. Murray (margemurray@earthlink.com)

A Film of One's Own

In January 2008, at the Joint Mathematics Meetings in San Diego, filmmaker George Csicsery premiered a sensitive portrayal of the life and work of the mathematical logician Julia Robinson (1919–1985), the Berkeley Ph.D. whose work was key to the solution of one of the most important open problems of the twentieth century. On the face of it, the film could easily be dismissed as unremarkable—just another tale of scientific discovery. But films about the lives of mathematicians are rare; films about the work of mathematicians are rarer still. And, until recently, films about *female* mathematicians have been virtually nonexistent.

Indeed, the production of *Julia Robinson and Hilbert's Tenth Problem* is the culmination of a sequence of remarkable events dating back to the 1990s, which sparked the imaginations of filmmakers and led to a flowering of popular books and films about mathematics. In 1993, Andrew Wiles announced—a bit prematurely, as it turned out—that he had proved Fermat's Last Theorem, a feat that had eluded mathematicians for nearly 350 years. Wiles completed the proof the following year. In that same year, 1994, John Nash won the Nobel Memorial Prize in Economics for work in game theory that constituted his 1950 Princeton Ph.D. thesis in mathematics. What made the Nobel all the more remarkable was the fact that Nash had been severely disabled by schizophrenia for the better part of thirty years. Both Wiles and Nash had compelling personal stories—and the theorems that made them famous were relatively easy to state in lay terms, even if the proofs were not.

The saga of Andrew Wiles' pursuit of Fermat made it to the screen first when, in 1996, Simon Singh directed *Fermat's Last Theorem* for BBC television. In 1997 the film was broadcast in the United States on PBS's *NOVA*, titled simply, *The Proof* [**16**]. Singh, a Ph.D. in physics from Cambridge University, had a grand vision for the film, which he later fully elaborated in the companion book, *Fermat's Enigma* [**15**]. In many ways, *The Proof* is still the finest film account of the history of a challenging problem, dramatized through the passions and motivations of those who ultimately completed its proof.

At about the same time, business journalist Sylvia Nasar became enthralled with the story of John Nash, and the result was her award-winning 1998 biography, *A Beautiful Mind* [**12**]. Nasar's book—unlike the film [**9**] loosely based upon it—pays meticulous attention to the personality of Nash, the social context of his life and work, and the dynamics of his illness and recovery, as seen through the eyes of literally hundreds of friends, family, and colleagues. Nasar makes clear that Nash's life, like most human lives, has been one of complexity, ambiguity, contradiction, and conflict. As a complex human portrait of a mathematician and of the mathematical community, it is an amazing achievement.

The story of Fermat's Last Theorem—unlike the story of Nash—includes a brief but significant appearance by a woman mathematician. Singh's book, much more than his film, emphasizes the work and struggles of Sophie Germain (1776–1831), who

provided a key step in the proof of Fermat. Germain, like many other early women mathematicians, worked largely in isolation from the mathematical community; she concealed her identity (and her gender) behind a man's name for many years, studying at L'École Polytechnique and introducing herself to Gauss as "Monsieur LeBlanc."

But it was David Auburn's play *Proof* [**1**]—which had its New York debut in 2000 with Mary-Louise Parker in the role of Catherine—which introduced large theatrical audiences to the idea of a female mathematician. *Proof* was, of course, an incredible hit, winning a Tony and a Pulitzer and ultimately made into a 2005 movie [**10**] starring the very un-Mary-Louise-Parker-like Gwyneth Paltrow as Catherine. No woman in mathematics had enjoyed such cinematic prominence before, unless you count Jill Clayburgh's Kate Gunziger, who adeptly proved the Snake Lemma in the 1980 film *It's My Turn* [**17**]. Unfortunately, Catherine is oddly reminiscent of Sophie Germain, strangely transported to the late 20th century, and given more than a touch of John Nash's mental instability. Catherine works secretively on a mysterious theorem in number theory—a cross between Fermat's Last Theorem and the Riemann Hypothesis, one of John Nash's longstanding preoccupations. But as many critics have observed (e.g., [**3**]), Auburn's most glaring omission in *Proof* is, well, the proof—that, and at least a century's worth of women in mathematics.

Enter George Csicsery. Around 1993, just as John Nash was coming to the attention of the Nobel committee and Wiles was wrapping up his work on Fermat, Csicsery—a Berkeley filmmaker of Hungarian descent—directed his first hour-long feature on the life and work of a mathematician: *N is a Number: A Portrait of Paul Erdős* [**4**]. Csicsery has no formal mathematical training, but became interested in the peripatetic Hungarian mathematician upon reading Paul Hoffman's 1987 article about him in *The Atlantic* [**7**, later expanded into **8**]. Erdős' chief claim to fame was his voracious appetite for mathematical collaboration, and as the film clearly demonstrates, many of Erdős' collaborators have been women—most notably, Vera Sós and Fan Chung. By displaying these collaborations, Csicsery became perhaps the first filmmaker to depict real women doing mathematics on screen.

In the years since *N is a Number*, Csicsery has made a project of committing mathematical lives to film. In 1998, on a tip from philosopher-polymath Charles L. Silver [**2**], Csicsery began work on the first feature devoted entirely to a woman mathematician: *Julia Robinson and Hilbert's Tenth Problem* (hereinafter, *JR & H10*). In structure, *JR & H10* is reminiscent of *The Proof*, as it interweaves the life of a great mathematician with that mathematician's dogged pursuit of a major theorem. But the film's guiding spirit is Constance Reid: Julia Robinson's older sister, biographer, and keeper of her legend and legacy. In 1996, Reid published a short book devoted to Julia Robinson's life and work, *Julia: A Life in Mathematics* [**13**]. If Paul Hoffman's article was the inspiration for *N is a Number*, Reid's book literally breathes life into *JR & H10*.

Like the book, the film proceeds—briskly, unsentimentally—through the often-tragic facts of Robinson's childhood: her birth in St. Louis in 1919; the death of her mother two years later; a cross-country move to be raised by grandparents; her father's remarriage and the reuniting of the family in California. In 1929, shortly after the birth of a baby stepsister, Robinson contracted scarlet fever, complicated by rheumatic fever and Sydenham's chorea. On the brink of adolescence, Robinson experienced a profound isolation: first the isolation of illness, then social isolation upon her recovery and return to school. When she had at last graduated from San Diego High School and had just gotten settled at San Diego State College—her life having at last some semblance of normalcy—Julia Robinson lost her father to suicide in 1937. In this great maelstrom of grief and loss, Robinson found solace and refuge in mathematics.

With the stage thus set, Csicsery shifts his focus from the personal history of Julia Robinson to the ongoing saga of the mathematical community she was about to join. Accompanied by rare film footage of the voice and visage of David Hilbert, a small squadron of mathematicians and logicians—including Dana Scott, Lenore Blum, Bjorn Poonen, Hilary Putnam, Steven Givant, and Solomon Feferman—endeavor to explicate the history and meaning of Hilbert's Tenth Problem: To devise an algorithm for determining, in a finite number of steps, whether a diophantine equation has integer solutions [**6**]. By the time Hilbert is heard uttering his famous credo, *Wir müssen wissen; wir werden wissen* (We must know; we will know), even mathematically unsophisticated viewers will have begun to suspect that—at least as far as the Tenth Problem is concerned—Hilbert was in for a disappointment.

Having provided this introduction to Hilbert's Tenth Problem, the film rejoins Julia Robinson's education, already in progress. In 1939 she made the fortuitous decision to transfer from San Diego State College to the University of California at Berkeley, where she met her future husband, mathematics professor Raphael Robinson; completed her B.A. in mathematics; married; and miscarried. The illness of Julia Robinson's early adolescence had taken its toll on her health, and it was generally agreed that her fragile health could not bear the stress of pregnancy and childbirth. According to Constance Reid, it was Raphael Robinson who assuaged Julia's disappointment by urging Julia to redirect her creativity toward mathematics.

In yet another astonishing stroke of serendipity, Robinson began work toward a Ph.D. in mathematics with Polish-born logician Alfred Tarski—who had himself arrived in Berkeley in 1942. While the film doesn't emphasize this, Julia Robinson was, in fact, the first of *four* women whose dissertations Tarski supervised during his first decade at Berkeley; like many émigré mathematicians of the period, he was extraordinarily welcoming to women students [**11**, 28–30]. Even so, Raphael Robinson seems to have served as something of an intermediary: he would talk mathematics with Tarski at lunch in the all-male faculty club, and then share Tarski's latest insights with Julia when he got home.

The American mathematical community in which Julia Robinson came of age was in some ways different from what it is today. Although Robinson was by no means the first woman to earn a Ph.D. in mathematics—roughly 300 women had come before her—she entered the professional world at a time when it was extraordinarily difficult for a woman mathematician to be taken seriously. In the United States, most major universities had anti-nepotism rules in place, which prevented a husband and wife from holding a professorship in the same department, and sometimes prevented them from being employed in any capacity by the same university (see, for example, [**5**] and [**11**]). In practice, these rules generally resulted in unemployment for the female spouse. At many American universities, many such discriminatory barriers to female faculty employment persisted until the passage of Title IX in 1972, and beyond.

When Julia Robinson completed her Ph.D. in 1948, antinepotism rules at Berkeley barred her from professorial employment there. As the Robinsons apparently never seriously considered moving elsewhere so that they might both have professorships, she worked for most of her mathematical life without benefit of a formal faculty position. Of course, Raphael Robinson provided her with mathematical companionship and an entrée to the wider mathematics community; but Julia Robinson did most of her mathematics in the kind of isolation which proved fatal to the research careers of many other women mathematicians of her generation (see [**11**]). That this isolation did not prove fatal to Julia Robinson's research is testament to her determination, tenacity, good fortune, and sheer passion for mathematics.

The balance of the film follows Julia Robinson's progress on the ultimate resolution of Hilbert's Tenth Problem. Working alone and in collaboration with Martin Davis, Hilary Putnam, and—much later—Yuri Matiyasevich, Robinson's work on the unsolvability of Hilbert's Tenth Problem spanned two decades. During these decades, Julia Robinson also channeled her formidable talents and energies into other arenas, including a lengthy foray into the political campaigns of Alan Cranston and Adlai Stevenson in the 1950s. In the film and elsewhere ([13], [14]), Constance Reid makes clear that her sister had a passion for public service which, in another time, might have led her to a political career of her own.

It's difficult to assess Constance Reid's suggestion that her sister wouldn't have *wanted* a regular faculty position during those years. Certainly many of Robinson's life-choices were altered by her health. But owing to a succession of surgical operations in the 1960s, much of the heart damage she sustained in her childhood illness was repaired or reversed. The years that followed were years of efflorescence: the resolution of H10; election to the National Academy of Sciences; a tenured faculty post at Berkeley (at last!); selection as a MacArthur fellow; and finally, election to the Presidency of the American Mathematical Society for 1983–84. And then, suddenly, leukemia brought the life of Julia Robinson to an end.

The life, perhaps; but Robinson's mathematics lives on. One of the great strengths of *JR & H10* is the testimony of generations of women in mathematics—from Anna Salamon, the 1998 Julia Robinson Prize winner at San Diego High School; to Kirsten Eisenträger (Ph.D. 2003), Assistant Professor at Penn State; to Alexandra Shlapentokh (Ph.D. 1988), Professor at East Carolina University; to Lenore Blum (Ph.D. 1968), Professor at Carnegie Mellon University—all of whom carry on the spirit of Robinson's life and work.

All in all, George Csicsery has filmed a loving tribute to Julia Robinson and a testament to her ability to transform adversity into creative triumph. Here is a film that's sure to inspire mathematics students of all ages and genders. And perhaps—just perhaps—*JR & H10* will inspire a new generation of filmmakers to tell richer, fuller, *truer* stories about the lives of mathematicians, male and female.

References

1. D. Auburn, *Proof*, Faber & Faber, New York NY, 2001.
2. B. Casselman, An interview with George Csicsery, *Notices Amer. Math. Soc.* **55** (2008) 576–578.
3. D. Castelvecchi, Proofs, women, and youth: A new movie and some old clichés (2005); available at the American Institute of Physics site, `http://www.aip.org/isns/reports/2005/017.html`.
4. G. Csicsery, director, *N Is a Number: A Portrait of Paul Erdős*; motion picture distributed by Zala Films, Oakland CA, 1993.
5. J. Green and J. LaDuke, *Pioneering Women in American Mathematics: The Pre-1940 Ph.D.'s*, American Mathematical Society, Providence RI, 2009.
6. D. Hilbert, Mathematical problems (trans. M. W. Newson), *Bull. Amer. Math. Soc.* **8** (1902) 437–439. Reprinted in *Bull. Amer. Math. Soc. (N.S.)* **37** (2000) 407–436.
7. P. Hoffman, The man who loves only numbers, *Atlantic Monthly* **250** (1987) 60–68, 70, 73–74.
8. ———, *The man who loved only numbers*, Hyperion, New York, 1998.
9. R. Howard, director, *A Beautiful Mind*; motion picture distributed by Universal Pictures/DreamWorks Pictures, Los Angeles, 2001.
10. J. Madden, director, *Proof*; motion picture distributed by Miramax Films, New York, 2005.
11. M. A. M. Murray, *Women Becoming Mathematicians: Creating a Professional Identity in Post-World War II America*. MIT Press, Cambridge MA, 2000.
12. S. Nasar, *A Beautiful Mind*, Simon & Schuster, New York, 1998.
13. C. Reid, *Julia: A Life in Mathematics*, Mathematical Association of America, Washington, DC, 1996.
14. ———. Being Julia Robinson's sister, *Notices Amer. Math. Soc.* **43** (1996) 1486–1492.