# Mathematics Takes Center Stage

Robert Osserman

It was just fifty years ago that mathematician Morris Kline, bothered by the general perception that mathematics was a subject divorced from the central concerns of society at large, took time out from his purely research activities to write the first of several books designed to demonstrate that precisely the opposite was true: mathematics is, and has been throughout history, absolutely central to a whole spectrum of human activities. His book *Mathematics in Western Culture* [6] appeared in 1953 and details not only the interweaving of mathematics with the sciences, but also with the arts, with philosophy, and with culture in general.

On the subject of Pierre de Fermat, whose highly original contributions to mathematics dazzled his contemporaries and earned him the title "Prince of Amateurs" by E. T. Bell [2], Kline writes "he lived an ordinary life as a lawyer and civil servant; at night, he indulged himself in mental sprees by creating and lavishly offering to the world million-dollar theorems."



Kline was obviously speaking metaphorically, at a time when the actual value of mathematical theorems was probably closer to five cents. He would have been incredulous had he been told that by the end of the century, there would be a number of mathematical theorems whose proofs would be *literally* worth a million dollars. Seven unsolved mathematical problems have been designated as "Millennium Prize Problems" by the recently founded Clay Mathematics Institute. At a widely publicized event held in Paris in the year 2000 to commemorate Hilbert's famous list of unsolved problems presented to the International Congress of Mathematicians in Paris in 1900, CMI issued their challenge and offer of a million dollars each for the solution of seven major problems, including the two oldest and perhaps most famous: the Riemann Hypothesis and the Poincaré Conjecture. In addition to those, an even older problem, the Goldbach Conjecture, was given a brief window as a literal million-dollar problem, when the publishers of Apostolos Doxiadis' book, *Uncle Petros and Goldbach's Conjecture*, offered a million-dollar prize for anyone who could find a solution within a limited period of time.

Perhaps nothing is more indicative of the radical change in the general view of mathematics than the surprising announcement that the annual „Jobs Rated Almanac" [7], a survey of public perception of job satisfaction, put statisticians and mathematicians in the first two out of 250 lines of work for "best working environment." The top ten choices for best overall job all involved some aspect of mathematics or computing. When Kline was writing, the average person would have been surprised to discover that mathematics was even a possible job category, rather than an academic subject from the distant past.



What accounts for the radical change not only in public awareness of mathematics but also in the shift from a rather negative stereotype of mathematicians to one that is far more favorable? There is no doubt that a major factor was the advent of computers. Oddly enough, the association between mathematics and computers in the mind of the public had little to do with the reality. For most people, mathematics *is* computing. The New York Times *Encyclopedic Almanac* for 1970, for example, has one page devoted to mathematics, a third of which is taken up with – of all things – a 25-by-25 multiplication table. It also includes the statement, "In recent years, computers have revolutionized mathematics." Nothing could have been further from the truth. In 1970 only a relative handful of research mathematicians had made any use whatever of a computer. They were much more likely to be part of the standard equipment of economists, psychologists, social scientists – anyone whose work involved dealing with large amounts of data, while they offered little to a mathematician devising new theories, defining new objects, trying to prove theorems or settle conjectures.

Much less known to the general public (and to the editors of the Times *Almanac*) was the real role of mathematicians vis-à-vis computers: that the basic ideas utilized in the construction of programmable computers were due to mathematicians like Turing and von Neumann. Furthermore, the important role of prototype computers in World War II was largely unknown, since much of it was long kept secret. But gradually that story emerged, along with the key role of mathematicians in the code-breaking efforts during the war. Again the name of Alan Turing appeared, in his heroic role in defeating the invincible-appearing German Enigma machine. The highly successful full-length biography, *Alan Turing: the Enigma*, by Andrew Hodges [5], appeared in 1983, and a large segment of the general public was treated to a view of mathematical activity that could only be described as significantly eye-opening.

It is a commonplace that art both reflects and influences society at large. During a period of transition, when broad changes are taking place, that dual role becomes self-reinforcing, creating a snowball effect. Something like that happened to the public perception of mathematics during the eighties and nineties, as an accelerating flood of books, plays, and movies depicted mathematicians, both real and fictional, and portrayed mathematical activities with varying degrees of accuracy.

Two events in the early nineties made headlines, and significantly increased public awareness of live mathematics. The first was the front-page news that Andrew Wiles announced his solution of the 350 year-old "world's most famous unsolved problem:" Fermat's Last Theorem. The second was the announcement that mathematician John Nash had been awarded a Nobel Prize for his early groundbreaking work on game theory. Both of those news items led to best-selling books: *Fermat's Enigma* [11] by Simon Singh (as well as several other books on the subject), and *A Beautiful Mind* [8] by Sylvia Nasar. In addition, there were two biographies of the amazingly prolific and idiosyncratic mathematician Paul Erdös.

But the greatest impact, and almost by definition the most dramatic, was that resulting from the ever more frequent depictions of mathematics on stage, in film and on television. Among the first was a play by Hugh Whitemore called "Breaking the Code" that was based on the Hodges biography of Turing. Derek Jacobi took the role of Turing both in the original production and in a later television version [16] that also features playwright and actor Harold Pinter.

When it comes to fictional mathematicians in the theater, the seminal work without question is the brilliant play "Arcadia" by Tom Stoppard [12]. The central character is the lively, charming, disarmingly brash young teenager Thomasina, who happens to be also a mathematical prodigy. Her tutor Septimus is well versed in mathematics and science, and much of their dialog, which takes place around 1810, reflects the latest developments in those subjects at that time. A parallel plot, set in the present day, involves a young population biologist whose role consists largely of interpreting the surviving 19th century notebooks, explaining them to the contemporary characters in the play, and relating them to his own use of modern mathematical methods. The typically intricate Stoppardian plot allows the interweaving of long bits of dialog devoted to a variety of sophisticated mathematical subjects, unlike anything else seen in an enormously popular play by a major playwright.

Stoppard did not put much significance in the fact that he had made his mathematical prodigy a young woman. But it is a curious fact that the majority of fictional mathematicians on stage and screen over the past two decades seems to have been women, in contrast to the ongoing concern about the scarcity of women in leading mathematics departments around the world. Some examples are:

"It's My Turn" (1980) in which Jill Clayburgh has the lead role as a research mathematician and professor at a major institution. She is portrayed in Hollywood fashion with an appealing personality, sex-appeal included, and she gets romantically involved with a major league baseball player (Michael Douglas). To add a touch of "reality" she has also to be a bit clumsy and absent-minded, but with a light touch.

"Presumed Innocent" (1991). Bonnie Bedelia plays a mathematics graduate student who has been working on her dissertation for ten years. Her husband Rusty (Harrison Ford) is the prime suspect in a murder case, but she is not above suspicion herself..

"Antonia's Line" (1995). Winner of the Academy Award for best foreign film of 1995. Five generations of strong-willed independent women. Antonia's daughter Danielle becomes a painter, and Danielle's daughter Thérese is a mathematical prodigy, with every cliché in the book: a lightning calculator at an early age, interested in nothing at school except math and music, marries after getting pregnant, but has not much time or interest in her daughter Sarah, and only marginal interest in her husband. Sarah becomes a writer, and is the one who recounts the whole story. (It is true that one can interpret Thérese's coldness in two ways – either as stereotypical math/scientist, or else as a consequence of having been brutally raped at a young age.)

By the time year 2000 rolled around, it may not be surprising in retrospect, but certainly seemed so a the time, when within a period of a few weeks three plays





opened in New York, all very different, but all having in common as a central character a young woman who is a kind of mathematical genius with a father who is also a prominent mathematician. One of them, "Hypatia", is based on the historical figure whose father Theon was a leading mathematician of the time, and who is the first well-known woman mathematician in Western history.

The other two plays are works of fiction. "The Five Hysterical Girls Theorem" by Rinne Groff is written in an absurdist style. Twelve of the eighteen characters are mathematicians, among them Moses Vaszonyi, an acknowledged mathematical genius. His daughter, not coincidentally named Hypatia, appears to have inherited his mathematical interest and talent. The dialog includes long stretches of mathematics, both real and imaginary.

The third play, "Proof" by David Auburn [1], was by far the most successful of the three. It moved on to Broadway in the fall of 2000, and received both the Pulitzer Prize for best dramatic work and the Tony Award for best new play. It has just four characters: Robert, a brilliant mathematician who was at the University of Chicago before suffering a nervous breakdown, Hal, one of his former students – now an instructor, and his two daughters Catherine and Claire. Claire is the only one who has left her father's mathematical sphere of influence. The central question of the play is whether Catherine has inherited her father's mathematical genius and/or his mental instability.

At the same time, male mathematicians and scientists were making their appearance with increasing frequency. More significantly, the way they were being portrayed was evolving rapidly. Reviewing three recent movies in which mathematicians played significant roles: "Presumed Innocent," "Sneakers" and "Jurassic Park", Constance Reid wrote in the Spring 1994 issue of Math Horizons, " The possibility of a star being a mathematician is very close to zero. The possibility of a realistic treatment of a mathematician is almost zero." On the second count she may be right, but along with everyone else, she must have been dumbfounded by what was just ahead for mathematicians in the cinema.

First in line was Jeff Bridges playing a math professor opposite English professor Barbara Streisand in the 1996 movie, "The Mirror has Two Faces". Immediately following was the 1997 movie "Good Will Hunting" in which Matt Damon plays a tough, brawling, bar-hopping denizen of South Boston who happens also to have a photographic memory and to be an untutored mathematical genius. The cult movie "Pi" from 1998, by director Darren Aronofsky, who went on to win a number of awards for his next film, "Requiem for a Dream," features another young mathematical genius who is subject to murderous migraine headaches, portrayed in chilling fashion.

In 2000 and 2001 Hollywood went all out in turning mathematical books into major motion pictures. The first was the film "Enigma", co-produced by Mick Jagger, and with a screenplay by Tom Stoppard. Based on the book of the same name by Robert Harris, its setting is the center of England's top-secret code-breaking efforts in World War II, Bletchley Park, and its chief protagonist is yet another mathematical genius, roughly modeled on Alan Turing. The second is based on the biography *A Beautiful Mind* [8]. It stars Russell Crowe of "Gladiator" fame as real-life mathematician and Nobel Prizewinner John Nash.

And so, mathematics has truly moved to center stage, in books and films as well as plays. The question that must be asked is: how accurate is the picture of mathematics and mathematicians that emerges out of all these depictions?

To start, let me note what seems to be a fundamental paradox that is of far broader scope than the particular case of mathematics. It is this: a writer, whether of biography or fiction, whether of books or plays, will naturally be drawn to a subject that is out of the ordinary, and more often than not, a story that is dramatic in some fashion. The reader, on the other hand, whose only exposure to a relatively esoteric subject is likely to be through these accounts, is almost guaranteed to form a picture that is correspondingly distorted. The question, then, is: if you had no other contact with mathematicians and if you diligently read and watched all these books, plays, and films over the past ten or twenty years, what picture would you form of mathematics and its practitioners?

The answer is glaringly obvious: mathematicians are either women or crazy – possibly both.

In the case of real-life mathematician John Nash, the portrayal is accurate. He was hospitalized for many years with a serious mental breakdown. In the New York Review of Books, under the heading "Varieties of Madness" [13], Joan Didion reviews the Nash Biography, *A Beautiful Mind*, together with the Unabomber manifesto. She points out that Time magazine refers to mathematician Theodore Kaczynski, the Unabomber, as a "mad genius," but that not everyone agrees to his insanity.

When it comes to fictional mathematicians, the record is impressive. The lead character, Max, in the movie "Pi," seems on the brink of a nervous breakdown, whether caused partly by his repeated excruciating migraines (or are they the result of his mental over-exertions?), by the confinement to his suffocating room with its enveloping patched- together computer system itself on the verge of permanent breakdown, or by his almost insane obsession with numbers.



Then there is mathematician Tom Jericho, the chief protagonist of the book and film, "Enigma" [4]. The book starts with Tom's mysterious return to Cambridge from Bletchley Park, sparking a storm of speculation, including "…he was a genius. He had had a nervous breakdown. …" all of which we are told, was "precisely correct."

And then Uncle Petros, in the book of Doxiadis mentioned earlier [3], refusing to settle for a career in which he would be acknowledged as a brilliant and original mathematician of his time but without the crowning glory of solving one of the great open problems of mathematics such as Goldbach's Conjecture. He manages to more or less literally drive himself crazy in the attempt. His mathematically gifted nephew concludes that "with the Scylla of mediocrity on the one side and the Charybdis of insanity on the other, I decided to abandon ship."

Finally, a central theme of the play "Proof" [1] is the mental breakdown of the father and the potential of his daughter following suit.

The question, as we have said, is to what degree all these pairings of mathematical genius with insanity reflect reality.

First, the case of "Enigma" is easy to answer. Tom Jericho, the protagonist, is loosely based on Alan Turing, who seemed to get through all the boiler-room



pressures of Bletchley Park during the war without any hint of a breakdown. He is sometimes cited (in *Uncle Petros*, in particular) as an example of mental instability because he later took his own life. However, there is little evidence that the reason was connected to his mathematical genius, and much more cause to attribute it to the manner in which he was hounded because of his homosexuality, and his being forced to take hormones as a "cure."

As for "Proof," author David Auburn tells us (in Gussow[14]), "I think there is some connection between extreme mathematical ability and craziness. I don't think that math drives people crazy, but those with edgy or slightly irrational personalities are drawn to it." (A similar opinion is expressed in yet another piece of mathematically-oriented fiction [10]: "There is an ethereal quality in mathematics that has always attracted disturbed minds.") But *New York Times* reviewer Bruce Weber appears to have no doubt as to causation. He writes [15] about daughter Catherine: "she has witnessed firsthand the jumble that mathematics can make of a working brain."

There is no question that in the popular mind, too intense and sustained mental efforts such as those required for wrestling with mathematical problems can lead to mental breakdowns. That belief is both reflected and reinforced by passages in *Enigma, Proof,* and *Uncle Petros.* In fact, in the last two, the protagonists suffer relapses after trying to get back to their mathematical activities. The movie "Pi" is summarized on the cover of the video as "a brilliant mathematician on the brink of insanity as he searches for an elusive numerical code," and there is an older mathematician who warns his younger protégé against pushing too hard, and the danger of breaking down.



What is the reality of the connection between concentrated mathematical activity and mental breakdowns? To the best of my knowledge, there has not been any serious scientific study of the question. Anecdotally, in a lifetime devoted to mathematics, during which I have had contact with many hundreds of mathematicians, including most of the Fields Medalists, I can think of one or two who then suffered a mental breakdown. During the same period I knew a number of non-mathematicians who were forced to spend time in mental hospitals, and my visits there left me with the impression that mental illness strikes individuals from the entire spectrum of society, without regard to profession, race, or class. A recent book by Daniel Nettle [9] reports on evidence that there is a correlation between creativity, or "strong imagination" and various psychological disorders. Several studies seem to indicate that despite the stereotypical "mad scientist," comparisons across professions put scientists among the least subject to mental illness, with writers and playwrights at the top. Of course, the category "scientists" include all the experimentalists, whose success depends on sustained practical and organizational efforts which may be precluded by repeated bouts of mental disorder. Sylvia Nasar [8], citing Harvard psychiatrist John G. Gunderson, concludes "Men of scientific genius, however eccentric, rarely become truly insane – the strongest evidence for the potentially protective nature of creativity." None of the studies single out mathematicians or theoretical physicists, and some aspects of the studies themselves are open to question.

Whatever the case may be, the association between genius and insanity remains a strong one in the popular mind, and clearly a subject of continued fascination for writers.

Luckily, not all writers. Tom Stoppard has said [18] on the subject of his character Thomasina, the teen-age mathematical prodigy, "Rightly or wrongly, I mean accurately or inaccurately, I made her in every other respect a perfectly ordinary young woman. … The idea of genius in novels and art very often present us with a most unusual kind of human being. … I guess when one thinks of Gödel, for example, in life that may very well be also true, that you'd notice these people if you saw them on a train, and so forth. But I like to think that they are, perhaps, the egregious ones. And most very, very clever people – I find this an attractive idea – that if there's ten people messing around with a basketball in a court, one of them could be a genius, but you wouldn't know which by just looking at them and listening to them. And I like that aspect of that character."

Finally, the most improbable of all the recent representations of mathematicians in the theater is in the musical comedy, "Fermat's Last Tango," whose central character, Daniel Keane, is a fictional portrayal of Andrew Wiles. It retells the story of Wiles' initial announcement that he had finally found a proof of Fermat's Last Theorem, followed by the discovery that, in the words of one of the musical numbers, the "proof contains a great big hole." He then struggles to fill the gap, and – on the brink of giving up – finally succeeds. Despite the format of a musical comedy (and apart from the amusing fantasy of Fermat himself appearing to taunt and tease Daniel Keane) the story line is a remarkably accurate portrayal of what Wiles went through, with no compunction about avoiding mathematical language or formulas. Wiles himself is portrayed as a generally sympathetic character, with no suggestion that he was at the risk of a mental breakdown during the period when he was under enormous pressure, in full public view to either complete the proof or admit that he was unable to do so. And indeed, the same is true of the real-life Wiles, who, incidentally, is an even more sympathetic and appealing character then his stage portrayal. The authors of "Fermat's Last Tango," Joshua Rosenblum and Joanne Sydney Lessner had never met Wiles, and had only read his story in popular books.

The Clay Mathematics Institute, in addition to its offer of seven prizes of a million dollars each for the solution of seven mathematical problems, has done its bit to further mathematics in our culture by making a high-quality video recording of "Fermat's Last Tango" before the end of its original run in New York, which they have made available both on tape and DVD [17]. For a different view of mathematics and the theater, where mathematical genius is associated with song, dance, wit, and a little love interest, a viewer could do worse than to spend ninety minutes with this romp.





## References

### Books


[1] D. Auburn (2001) *Proof*, Faber and Faber, New York.
[2] E.T. Bell (1986) *Men of Mathematics,* Touchstone Edition, Simon and Schuster, New York, p. 56.
[3] A. Doxiadis (2000) *Uncle Petros and Goldbach's Conjecture*, Bloomsbury
[4] R. Harris (1995) *Enigma*, Random House, New York.
[5] A. Hodges (1983) *Alan Turing: The Enigma*, Simon & Schuster, New York.
[6] M. Kline (1953) *Mathematics in Western Culture*, Oxford University Press, Oxford.
[7] L. Krantz (2000) *Jobs Rated Almanac*, St. Martin's Griffin, reported in the San Francisco Chronicle, Sept. 1, 2000, pp. B1, B3.
[8] S. Nasar (1999) *A Beautiful Mind,* Touchstone Edition, Simon & Schuster, New York, p. 16.
[9] D. Nettle (2001) *Strong Imagination: Madness, Creativity and Numan Nature*, Oxford University Press, Oxford, pp.143-147.
[10] P. Schogt (2000) *The Wild Numbers*, Four Walls Eight Windows
[11] S. Singh (1997) *Fermat's Enigma*, Anchor/Doubleday, New York
[12] T. Stoppard (1993) *Arcadia*, Faber and Faber, London.


### Articles


[13] J. Didion (1998) Varieties of Madness, *New York Review of Books*, April 23.
[14] M. Gussow (2000) With Math, a Playwright Explores a Family in Stress, *New York Times*, May 29, P. B3.
[15] B. Weber (2000) A Common Heart and an Uncommon Brain, *New York Times*, May 24, P. B1.


### Videos


[16] Breaking the Code (1997), by H. Whitemore, Mobil Masterpiece Theatre.
[17] *Fermat's Last Tango* (2001), Clay Mathematics Institute.
[18] Mathematics in Arcadia: Tom Stoppard in Conversation with Robert Osserman, (1999) Mathematical Sciences Research Institute.


### Additional book


[19] M. Emmer and M. Manaresi, eds. *Mathematics, Art, Technology and Cinema,* Springer-Verlag, Berlin 2003