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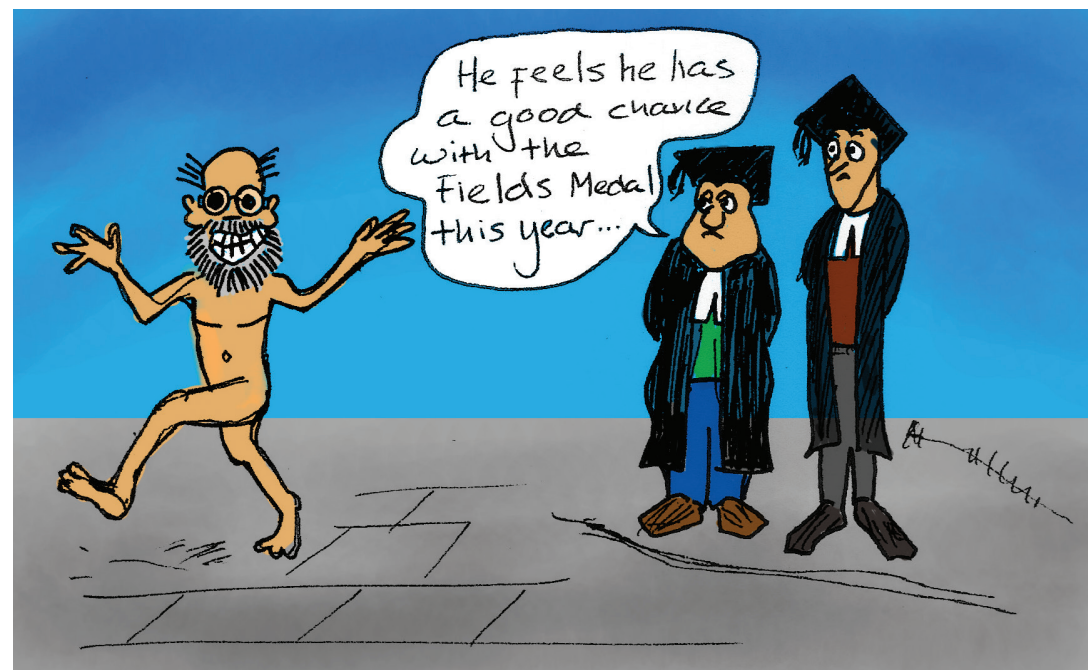
What's Love Got to Do With It?

Edward Frenkel is writing a protracted Dear John letter to popular misconceptions about math and mathematicians...

The great popular science and science fiction author Isaac Asimov told a story about a university committee meeting in which there was much laughter and joking about a student named "Milton" flunking English literature, but no one noticed when a student named "Gauss" was failing in mathematics. I wish I could find the reference to this, but I read it long ago in childhood, and some Internet searching proved fruitless. I may have the details wrong – especially the name of the student flunking English literature – but I remember the point. Asimov complained that a scientist would be thought a Philistine if he expressed no interest in music or philosophy, but that an artist could boast about not knowing enough arithmetic to balance his checkbook.

Edward Frenkel is one of the great mathematicians in the world, and he made a similar point much more recently. "Intelligent people would never say: 'I don't care about art or music.' But it is totally okay to say: 'I hate math.'" Asimov's solution was to give up science and devote himself to explaining mathematics and science in an enormous body of fiction and nonfiction writing, as well as public speaking. Although he stopped doing research in 1958, he remained one of the most popular lecturers at Boston University until near his death. His stories inspired 26 movies, shorts, and television shows.

Frenkel has continued his meteoric career in mathematics, so his public education efforts to



date are smaller than Asimov's. They also have a different slant. Asimov tried to show everyone how mathematics and science could be fun. Frenkel instead celebrates the passion and intensity of mathematics at the highest level. He has done this through lectures which are a sensation on YouTube, an erotic film, and, most recently, a book, *Love and Math: The Heart of Hidden Reality*.

Frenkel's film was motivated in part by the observation that the most popular mathematics movies portray: "a mathematician is on the verge of a mental illness." I assume he is thinking about movies like *Pi*, *A Beautiful Mind*, *Proof*, and *Good Will Hunting*. To be fair, there are sane mathematicians in these movies (but they are never as brilliant as the crazy ones) and *A Beautiful Mind* did not exaggerate the facts of John Nash's mental problems. But I agree with Frenkel that movies are apt to suggest that mathematicians are either mediocre and dull, or brilliant and psychotically obsessed.

One interesting comparison is to artists, musi-

cians, and writers. With these people, screenwriters often assume they must be tortured to be authentic. But there are plenty of exceptions – movies built around well-rounded, friendly, artistic geniuses. And, even when artists are a bit crazy, it is an excess of passion, "agony and ecstasy," not some incomprehensible twisted obsession from another dimension. The troubled artist is too human, the mathematician is inhuman. The artist gains relief by completing work, and that work is appreciated by others. The mathematician's frenzied quest just drives him deeper into obscurity and incomprehensibility.

It's also interesting to think about the media treatment of real-life pure mathematician Grigori Perelman, who proved the Poincaré conjecture, then turned down the Fields medal and the \$1 million Millennium Prize, among other honors. He explains himself clearly. He does not want to be a pet or celebrity, he does not want awards from people who aren't qualified to judge his work, he is not interested in money, and he is unhappy with

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the extent that professional mathematics tolerates unethical conduct. He wants to do his math in peace, and share it with honest people who understand it (it's not clear if he continues to do math or not).

I think in any artist or philosopher this behavior would be celebrated as authentic and simple honesty. Think of the kudos that Jean-Paul Sartre got for declining the *Légion d'honneur* and the Nobel Prize for literature, or the credibility that George C. Scott and Marlon Brando got for turning down their Academy Awards. All three cited reasons in the general ballpark of Perelman's. Yet, among these four people, only Perelman is portrayed as a certifiable lunatic whose actions are irrational. Artists kill themselves, rock stars die of drug overdoses, political activists blow up strangers or set themselves on fire; all these things enhance their reputations. But a mathematician must be crazy to love math and want peace.

A third comparison is to the personable and happy mathematicians in popular fiction, like Charlie Epps of *Numb3rs* and Ian Malcolm of *Jurassic Park*. Although Epps is described as a pure mathematician, his joy comes from applications. In a generic *Numb3rs* plot, Epps is given a puzzle relating to a crime and he sees the mathematical connection to some simple physical or social phenomena. While he generally disappears to a computer or see-through erasable board to work out the details offscreen, the emotional high point is when he explains the advanced mathematical concept in terms that the FBI agents and the television audience can understand. While these sidebars are not always integrally related to the plot, they are usually both interesting and mathematically sound. Moreover, Epps' noncrime-solving research includes cosmology and the mathematical basis of consciousness, either of which could be either pure or applied work, but tellingly they are described in their applied terms.

Malcolm is even more radically applied. He has convinced himself that pure mathematics is just a formal game, reasoning from axioms to theorems, with no larger pattern or meaning. Therefore, he calls himself a "chaotician" and works mainly with computer simulations of problems of practical interest. The principles he espouses are empirical, such as: "life finds a way," rather than logical.

The key seems to be whether the individual is tethered to reality. It's okay to lose yourself in abstraction, to see things no one else sees, to care passionately about things no one else can understand; as long as you return to general intelligibility with solutions to real problems, or works that other people can see and understand. Then you can be charmingly eccentric and happy. But if you are tourist rather than explorer, if you journey into abstraction for the joy of it, the popular fiction con-

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vention seems to be that you are unstable, miserable, unsociable, and dangerous.

Edward Frenkel – unlike Isaac Asimov, Michael Crichton (the inventor of Dr. Ian Malcolm), and the creators of *Numb3rs* – seems to want to challenge this compromise. He holds himself out unapologetically as a pure mathematician, exploring abstract relationships for the love of it. He does make a few noises about the applicability of some mathematics, but it's always the same quantum physics and public key cryptography and, as discussed below, he's half-hearted about that. He wants to tell us about the fierce emotions he feels: fear, doubt, disappointment, joy, and triumph; and he's not ashamed to

put mathematics up there with great art, or with concepts as fundamentally human as sex and death.

The first step in Frenkel's unorthodox strategy is to include brief but poignant autobiographical details. He skillfully sketches a character who is shy and brilliant, tough and sensitive. He has the great misfortune to be born under Communism, and in particular to be Jewish (according to USSR ethnicity rules, that is) in Russia in the 1980s. Yet, he is extraordinarily fortunate in his mentors and colleagues, and in opportunities like being offered a visiting professorship to Harvard as a 21-year-old without a graduate degree (and in being allowed to accept it and emigrate to the West in 1990). He illustrates his personality through sharp portraits of incidents like disappointing his mentor by refusing the return to Russia or confronting a blustering apparatchik bigot, inexplicably invited to lecture at MIT.

His autobiography is interspersed with accounts of some of his mathematical researches. He explains the problems in simple terms, but, unlike Charlie Epps, he does not try to motivate them. Anyone can follow his definitions of braid groups and his discussion of his explorations. They take no mathematical interest or training, although a nonmathematical reader will have to

plow through an unfamiliar amount of unmotivated details.

Why does he tackle these problems? Because it's fun and challenging. If that were the whole story, he would be like an applied mathematician, or even a recreational one. He makes clear that there is another factor. His problem choices are guided by professional mathematicians who feel that the answers will open up new areas for exploration. He feels keenly the fear that he is working on an insoluble problem, or one with no elegant or useful answer, or one he is unequipped to solve. Yet, that thrills him as much as daunts him. But when he finds the answers, he treasures having discovered

universal truth, unknown to any other human. Writing up formal proofs is a tedious ordeal.

There is an underlying assumption to that account, which Frenkel does not discuss. It's the reason that the fictional Ian Malcolm left pure mathematics, and to some extent the reason that I did. What if the path chosen by professional mathematicians doesn't lead anywhere? What if, a hundred years from now, mathematics will still be playing with the same kinds of question, with millions of pages of additional proofs but no more real insight into anything? What if another civilization at our level of intellectual development had entirely different advanced mathematics, neither better nor worse than ours? What if the whole thing is the equivalent of writing a computer program to grind out prime numbers or digits of pi eternally? Except that the computer is better at it. This is not the fear that a decade of your life will be wasted in an

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impossible or unproductive problem or, far worse, a false proof, this is the fear that every effort in pure mathematics is wasted.

Some people have faith in pure mathematics because results that are obscure when first proved have frequently turned out to be of central importance to pure or applied problems many years later, in completely unexpected ways. And, sometimes, scientific hypotheses made for reasons of mathematical elegance have turned out to be closer to the truth than what we learn from painstaking observation and experience, what Eugene Wigner called, "the unreasonable effectiveness of mathematics." Frenkel travels a little down this road, citing non-Euclidian geometry and group theory, and also the applications of mathematics to quantum physics and cryptography. But these are mechanical, slapdash references compared to the vitality and incisiveness of the rest of the book (Mario Livio wrote an excellent book, *Is God a Mathematician*, that makes a much stronger case).

Cryptography is actually a bad example. Yes, the initial insights were made by pure mathematicians. But they needn't have been; people could have come up with the same algorithms from general principles in computer science, or even by inspired trial and error. The actual algorithms in use are only distantly and theoretically related to anything imagined by a pure mathematician. Pure mathematics gives us important insights but cryptography has been an engineering discipline for many years; it left mathematics at least 50 years ago.

Physics is a better example, but in the last 50 years it's not clear how much pure mathematics has added. If string theory, or some other advanced pure mathematical grand unification theory, proves out, then Frenkel has one modern example to buttress his case. If it doesn't, then he has none. In my lifetime, it's hard to come up

with an advanced pure mathematical insight that demonstrates practical utility. The point is not that mathematics has to be useful to be worthwhile, it's that practical utility gives confidence that mathematics is not wandering aimlessly in an infinite forest with no part essentially different from any other.

I'm not trying to make the case against pure mathematics; I lean in its favor, and I consider it primarily an empirical question. I don't lean strongly enough to devote my life to it, but I'd bet it will prove to be nonarbitrary and I certainly hope it does. I think Frenkel's faith is different, mainly because he's a lot better at pure math. I think he feels the connections and symmetries he and others are working to prove. Where I see multihundred-page proofs that can only be verified through years of intense work by top mathematicians – or gigantic computer computations – he seems to see pieces fitting perfectly into a jigsaw puzzle. He celebrates the theoretical certainty of a proof, I see the

shaky chain of human and computer judgments that make it less certain that a lot of mundane everyday things. We know of no reason why the earth's magnetic field won't reverse tomorrow; it's done it often in the past, but this would surprise me a lot more than if I learned that a major mathematical proof that has been widely accepted turned out to have a flaw.

I feel a lot of the things that Frenkel feels when I do applied mathematics. There is far less fear, and perhaps therefore less thrill. I know it's not as eternal or certain, but I'm confident that it's meaningful and useful. It's the difference between craftsmanship and art.

Frenkel has done an extraordinary job of making his case for love and mathematics. I think a lot of nonmathematicians will gain appreciation for the field, in the way that Stephen Hawking's *A Brief History of Time* delivered cutting-edge cosmology to the masses. It's not just the clarity of the thought or the skillful writing; in both cases, one of the best practitioners in the world has opened himself up personally to communicate deep ideas. I also think there are amateur and applied mathematicians who will come away with a refreshed understanding of the state of pure mathematics. On a lesser note, but still important, it's a nice antidote to the recent spate of Big Proof pure mathematics books that treat math like a treasure hunt. In that respect, I would compare it to the delightful novel, *The Parrot's Theorem*.

This is a serious and important book. It does not have the feel of a classic, however; it feels like the opening chapter of a larger body of work. Isaac Asimov, another Russian nonreligious Jew, was born 48 years earlier and 500 miles west of Frenkel, near the border with Belarus. He also emigrated to the United States, graduated from college at 19, and quickly earned a Masters in Chemistry from Columbia. If you subtract the six years he took out for World War II, he got his Ph.D. at the same age as Frenkel. He published his first book at age 30, five years younger than Frenkel, but went on to produce over 500 books, stories, screenplays, and other written works. While Frenkel seems unlikely to match that total, given his later start and full-time research work, we can hope for some more stimulating efforts to humanize mathematics.