BOOKS & ARTS

Bridging the gender gap in Indian science

A set of biographies reveals the trials and triumphs of India's women researchers, says **Asha Gopinathan**.

Lilavati was the clever daughter of the twelfth-century Indian mathematician Bhaskara II. A well-known mathematician in her own right, she inspired generations of Indian women. Bhaskara's famous book on mathematics was named after her, and he addressed many of its verses to her. *Lilavati's Daughters* spotlights women based in India who have pursued research in science, engineering and mathematics from the late nineteenth century to today.

A collection of 98 short biographies, the book stems from a project initiated by the Women in Science panel of the Indian Academy of Sciences, Bangalore, to provide young girls with inspiring role models (see www.ias.ac.in/womeninscience). The diverse personal stories span many disciplines and regions of India — and are inspiring.

The earliest chronological entry is for Anandibai Joshi, the first Indian woman to go abroad and study to become a doctor. From 1883 to 1886 she attended the Women's Medical College in Philadelphia and was awarded an MD degree for her thesis *Obstetrics Among Aryan Hindoos*. Unfortunately, she contracted tuberculosis and had to return to India. She received no treatment: Western doctors refused to treat a brown woman and Indian doctors would not help her because she had broken societal rules. Joshi died in 1887 at 22 years of age.

Thankfully, not all the women in the book had such tragic lives, although many had to overcome obstacles to achieve success. Physicist Anna Mani, who worked with the Nobel laureate C. V. Raman, was not awarded a doctorate despite publishing several single-author papers. Yet she went on to become the deputy director-general of the Indian Meteorological Department and, after retirement, set up a factory to manufacture instruments to measure wind speed and solar energy.

Lilavati's Daughters: The Women Scientists of India
Edited by Rohini Godbole and Ram Ramaswamy
Indian Academy of Sciences: 2008. 369 pp. 300 rupees, $25 (pbk)
See http://tinyurl.com/liladaug

Many of those highlighted were the first to break into male-dominated professions: Asima Chatterjee was the first Indian woman to be awarded a DSc; E. K. Janaki Ammal was elected a fellow of the Indian Academy of Sciences the year it was founded; Kamala Sohonie was the first female director of the Institute of Science, Mumbai; and Bimla Buti is a former director of plasma physics at the International Centre for Theoretical Physics in Trieste, Italy.

It is interesting that many of these women scientists came from ordinary middle-class families. Most grew up not in the nation's big cities but in rural areas, where getting an education in any discipline, let alone in science, is difficult. In rural Punjab, mathematician R. J. Hans-Gill had to pretend to be a boy and wear a turban to attend school — a secret that was kept between her family and the headmaster. Biologist Chitra Mandal was accompanied to school in rural Bengal by her grandmother because the teacher would not let the four-year-old in without someone to look after her.

R. RAMASWAMY

Attending a science summer school encouraged geneticist Sudha Bhattacharya to become a researcher.

Almost all of the women speak of the premium their families placed on education and the support and encouragement each received from family members. Mothers are especially significant — poorly educated ones as well as some who were scientists themselves. Dedicated teachers, both at school and college, were also influential. They spotted and nurtured talent and lit sparks of curiosity in the minds of these young girls. In post-independence India, government schemes such as the National Science Talent Search scholarship have helped many women, including geneticist Sudha Bhattacharya, now a professor at Jawaharlal Nehru University in New Delhi, to pursue their dreams by allowing them to study at a good university and to meet eminent scientists and peers from across the country during summer camps.

The road to the top is never smooth. Many of the women acknowledge sexism in their professions, a lack of institutional support, double standards in measuring their achievements, social bias due to caste, self-imposed limitations, negative stereotypes surrounding single women and the multiple roles that married women with families have to juggle. They have used many strategies for survival. But most important is their passion for their work.

The motivations of these female scientists are often surprising. Not everyone in the book aspired to win the Shanti Swarup Bhatnagar Prize for Science and Technology: only a handful has won this coveted award. Instead, they have put their energies into teaching and communicating science, taking their research out of the lab to change people's lives.

Each of these essays is special. They tell of vibrant women who combine a tough life in the sciences with other interests such as cricket, dance, music or literature. Had I received this book as a young girl, I would have been captivated. I hope that *Lilavati's Daughters* will be translated into many languages and grace libraries worldwide. It is a wonderful resource for both mentors and mentees. ■

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The many faces of mathematics

Mathematicians: An Outer View of the Inner World
by Mariana Cook
Princeton University Press: 2009.
208 pp. $35, £24.95

Recountings: Conversations with MIT Mathematicians
by Joel Segel
AK Peters: 2009. 330 pp. $49

The question of how one makes a great scientific discovery, or teaches others to do so, is central to two recent books that portray mathematicians. In *Mathematicians*, Mariana Cook photographs more than 90 living mathematicians, each portrait accompanied by an explanation of how they became interested in their subject. Many cite an early introduction to problem solving, often before the age of ten, by a family member. For others, it was a teacher who piqued their interest in mathematics. Later influences came from mentors or leaders in the field — Alexander Grothendeick is named by several as having suggested what they should work on.

Collaboration, such as that between Benedict Gross and Don Zagier on their eponymous formula or between Isadore Singer and Michael Atiyah on their index theorem, can be decisive in achieving a successful research career. Also important is sustained concentration on a problem: Jean-Pierre Serre says his best work is done at night when half-asleep. A background in music is another frequent theme: Timothy Gowers and Persi Diaconis both come from families of professional musicians, and Noam Elkies and Manjul Bhargava note an early interest in the patterns of Western and Indian classical music, respectively.


M. COOK

Timothy Gowers: music inspired maths.

Recountings tells of the influential US mathematics department at the Massachusetts Institute of Technology (MIT) through interviews with a dozen faculty members by author Joel Segel. The book was compiled after the sudden early death of Gian-Carlo Rota, MIT professor of applied mathematics and philosophy, when his colleague Gilbert Strang became concerned that reflections on mathematics and the story of the department might be lost with the passing of other senior faculty members. Also interviewed is Zipporah Levinson, the widow of Norman Levinson, a past department chairman who is revered both for his mathematics and for his able running of the department.

The interest in teaching among these senior faculty members is broad and deep. Many textbooks have arisen from MIT courses, such as George Thomas's classic text *Calculus and Analytic Geometry* (Addison-Wesley, 1952). The collective pride is palpable as many remember the day in 1959 when maths courses became catalogued as equivalent to others at MIT — no longer carrying an 'M' prefix to indicate that maths was a service department for the others. The professors share their strategies for achieving research success, from working on prize problems to developing an intuitive feel for proofs. They explain how new research directions have come from interactions with students and colleagues or from writing a review article.

Bertram Kostant's account is particularly inspiring and appears in both books. His interest in science began with his chemistry teacher, Mr Lieberman at Stuyvesant High School in New York, and listing the formulae in chemical reactions. Wherever Kostant went — from college at Purdue University, by way of the University of Chicago, the Institute for Advanced Study in Princeton, the University of California, Berkeley, to MIT — he found himself in the midst of a maths department at a high point. He was also tied to history. At Purdue he was taught by Arthur Rosenthal, a German refugee who had previously taught physicist Werner Heisenberg and had studied under C. L. F. Lindemann — who proved that π is not an algebraic number.

Years later at Princeton, Kostant drove Albert Einstein home just a week before Einstein's sudden death. Lingering in the car, Einstein asked Kostant what he worked on. "Lie groups," he replied, to which Einstein responded, "Oh, that will be very important." The great man's prophetic reply shows that his legendary intuition extended from physics to mathematics. On a different scale, the insights in these two books will inspire mathematicians and scientists to come. ■

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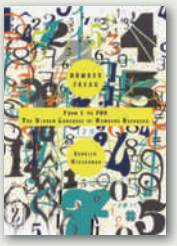
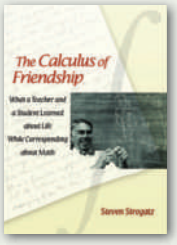
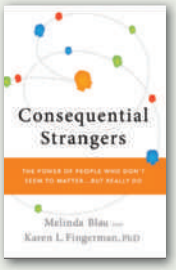
NUMERICAL READING



In *Number Freak* (Perigee Books, 2009), Derrick Niederman tells the stories behind the numerals 1 to 200. Each number gets an entry, detailing its significance from ancient myth to mathematical reality. For instance, the prime number 17 is considered unlucky in Italy and was detested by the Pythagoreans compared with its neighbours 16 and 18; yet the choreographer George Balanchine saw its beauty in a double-diamond configuration of 17 dancers in his ballet *Serenade*.



An intimate view of mentorship is revealed by US mathematician Steven Strogatz in *The Calculus of Friendship* (Princeton University Press, 2009), a compilation of letters exchanged with his high-school maths teacher over 30 years. Through their correspondence they share problems in calculus, chaos theory and major life events, from professional and sporting successes to family bereavements and divorce. The book touchingly charts their changing roles and relationship, from student to professor, teacher to retirement.



Numerous contacts with neighbours or workmates have a profound effect on our success, happiness and health, according to journalist Melinda Blau and psychologist Karen Fingerman. In *Consequential Strangers* (W. W. Norton, 2009), they explain how casual acquaintances are most likely to tip you off about a new job or provide a creative solution to a problem. Even though wide social networks can encourage bullying, lying and gossip, they enable people to become more conscious of their shared humanity.

Q&A: Science pop songsters

The US band They Might Be Giants has played rock to adults for more than two decades — and to children since 2002. Next week it releases the album *Here Comes Science*, with educational tunes about the elements and evolution. **John Linnell**, who fronts the band with John Flansburgh, explains why a science-friendly thread runs through their music.

Your 1987 remake of the 1959 children's song 'Why Does the Sun Shine?' is still popular. Why did you cover it?
We have songs about science and also about the pro-science culture of our childhood — the post-war science boosterism that was going on. The science record that we covered that track from was part of the post-Sputnik period in US history when there was a lot of interest in getting kids into science.

Was science a missed calling?
I would have been a crummy scientist but I would have been enthusiastic. I like science a lot and it's something that I think about all the time, almost as an amateur. It was a nice convergence of personal interests and a logical next step that we did an album about science.


S. GRIES/GETTY

John Linnell (above left) and John Flansburgh of They Might Be Giants hope their next album for children (inset) will help boost interest in science.

How does this follow on from your previous records for children?
We put out *Here Come the ABCs* as a placeholder. We were not overly concerned about teaching kids the alphabet because they are going to learn the alphabet anyway. It was a pretext for entertainment. The follow-up with the numbers was an obvious choice — although we were resistant to doing the *Here Come the 123s* because it was so obvious. Science was a departure from that pattern. And that was really exciting. We got to do something personal to us with the full promotional machinery of the Disney corporation behind it.

From the first song, 'Science is Real', this album seems to be making a statement. Why is that important?
It seems that science has suffered in this country recently, so it was political in a way. There has been some scepticism about science in the past 25 years that has been unfortunate. There's a decadent quality to that — that the culture has lost its way.

Your lyrics talk about evolution being real and how stories about angels and unicorns are just that, stories. Did you worry that this might alienate some listeners?
John Flansburgh took the bull by the horns by writing that song and addressing that situation, which is that religion cannot take the place of science. It's not something you can tiptoe around. It's important that everybody gets what the discussion is about. If we're talking about the history of Earth, we can't rely on religious tradition to tell us all the information. He says it in the song: as beautiful as the stories are, they don't tell us everything we need to know. It's an old complaint on the part of scientists, but it bears repeating.

Did you hire a fact-checker?
We did. Eric Siegel from the New York Hall of Science listened to everything and gave us very useful information, only some of which we entirely comprehended. He was pointing out, also, things in the videos that were misleading or not making the point in the right way.

In the new album you write a musical retraction: 'Why Does the Sun Really Shine?' Why set the record straight?
We overstated the case in saying that the original song is fatally flawed, because a lot of the information in it is good. The Sun does convert hydrogen into helium and there's a nuclear reaction and that's the source of the explosive radiative energy coming out of the Sun. The only thing that was seriously wrong with the original song is that the Sun is not gas, it's plasma. It's one of those modern distinctions that was lost on the writers in the fifties.

What's next?
I wish we could do a second volume of the science because there's a lot more stuff we haven't covered. I don't know, maybe that's going to be our next move. We could spend a lot more time on science. ■

Interview by **Brendan Maher**, *Nature*'s Biology Features Editor.

***Here Comes Science* will be released digitally on 1 September, and as a CD/DVD set on 22 September on Idlewild/Disney Sound.**