Article

Women of Sciences

by Purnima Tiwari

For a person in Science, especially mathematics, one must have come across a well-known and appreciated book, titled 'Men of Mathematics' by E.T. Bell, which is a beautifully penned piece of mathematical literature and talks about the lives of men from the history of Mathematics. But what impresses one is that the book doesn't limit itself to their lives in academia, we see their lives overall, looking beyond their works, into their interests, their hobbies, where some such as Archimedes fought wars for their kings, or some like Galois revolutionized the course of mathematics at a tender age of 19, and some like Descartes, who laid the groundwork for Geometry but however became a slave to his poor health.

When talking about Women in Sciences, the word *in* limits itself to the multitudes of dimensions which *of* can offer. Through this article, I aim to bring to light the women who have emerged elegantly in the diverse fields of Sciences, against the prejudice of the time.

Ada Lovelace, (1815-52)

Lovelace was born to Annabella Byron and Lord Byron in the first year of their marriage. Annabella was herself mathematically talented and was called *'The Princess of Parallelograms'* by Byron. Byron and Annabella's marriage was short lived and Lovelace didn't get her fair share of experiencing the love of her father.

Her interest in mathematics was initially pursued by Annabella, who was concerned about the insanity of Byron's nature that might have been of interest to Lovelace because of his intellect, but towards the end, she had developed a keen interest in the discipline for herself. Annabella was determined to make Lovelace self-dependent and at a very young age, exposed her to the beautiful world of mathematics. Lovelace's mother ensured that she was given the best education possible of the time, and the famous logician De Morgan was also one of the tutors of Lovelace when she was 8.

Lovelace, by the age of 12 had developed a zest for Mechanics. She had somehow become fluent in writing papers, and never missed an opportunity to do so, especially when she encountered Charles Babbage at a reception at the age of 17.

Babbage was in his early 40s, and didn't wait much longer before revealing to Lovelace, the prototype of the working model of 'The Difference Engine'. Ada was highly impressed and

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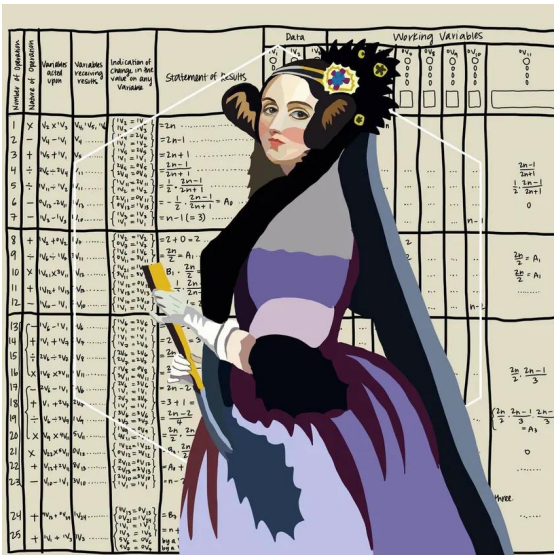

Fig: Ada Lovelace Courtesy of Sumana Mahata

rather intrigued by his ideas and this led to the start of a correspondence that the mathematical and the computational world has undoubtedly benefited from.

Lovelace was quite interested in Babbage's second project, called the 'The Analytical Engine' in which she had contributed a great deal. This project was supposed to be a major step-up from the first one, since it could do more than just simple calculations and solving polynomial equations of lower degrees.

Lovelace had designed a program to generate the Bernoulli's numbers using the Analytical Engine and had also imagined a vision of a working machine that could process graphics, such as musical notes, letters, images, etc. And perhaps rightfully, the programming language 'Ada' is named after her.

What fascinates one about Lovelace is that a century before the first programmable computer was designed, Lovelace had written a computer program. She had built connections with people such as Charles Babbage, Charles Dickens and Michael Faraday, and had achieved much by the young age of 36, when she died of cancer and was buried next to her father's grave.

Lovelace would describe her mindset as *'poetically scientific'* and expressed her views on imagination boldly, as-

"What is imagination?
It is a God-like, a noble faculty. It renders earth tolerable, it teaches us to live, in the tone of the eternal."

The 'Father of computer himself' named her as *'The Enchantress of Numbers'* and her life has been documented in a novel by Jennifer Chiaverini, by the same name- 'The Enchantress of Numbers: A Novel of Ada Lovelace'.

Marie-Sophie Germain, (1776-31)

Germain was a French Mathematician, Physicist and a Philosopher, who was determined to work independently throughout her life, due to the prejudice against her gender. She had no former education and taught herself all the necessary mathematics to catch up on the notable works of the time. Her interest in studying was demotivated and protested against by her parents, only to later realize that nothing could stop Germain. Her parents went so far as to not provide her with any heat at night so that she wouldn't dare to leave the room, but even that did not stop Germain and she continued to *sneak* into her father's library and read.

Germain, at a very young age was exposed to political and philosophical discussions and she was around the age of 13 when she used to visit her father's library and pass the time reading. Coming across Étienne Montucla's *Histoire des Mathématiques*, Germain read of his account of Archimedes who was so indulged in doing, pursuing, or rather *living* mathematics, that he would forget to eat and drink and at the end of the day, was killed at the hands of a Roman Soldier because of the same. She was moved by this and henceforth determined to be *'living'* mathematics, for the rest of her life.

Germain never married, and neither was she honored with a position in academia but despite that, her father eventually realizing her passion for the discipline, continued to support her financially throughout her life.

All that she knew about the discipline, until the age of 18, was self-taught. She was tackling concepts like differential and integral calculus, during the 'Reign of Terror', which we believe, brought her comfort during those times. Her house was a few feet away from the land of bombardments, during the time of the revolution and indeed, nothing could stop her.

Germain established connections with a professor at the *Ecole Polytechnique*, a new university at the time, and despite the restriction for women to study, she managed to obtain lecture notes from the professors, and even submitted an assignment that caught Legendre's eye, primarily because of it's originality. However, she had aliased herself as *M LeBlanc*, a student that had formerly studied there but passed away. Legendre was marvelled at the brilliant mind of LeBlanc, and emphasized on meeting *him*. However, he was more amazed when he figured that M LeBlanc, was actually a *'she'*, and then introduced Germain to his circle of scientists and mathematicians. Germain's correspondence with the academic world doesn't stop there. Later, she got interested in Number Theory, specifically, Fermat's Last Theorem, and corresponded with Gauss under the alias and even he was amazed at the marvellous mind of the young M LeBlanc, and more so when he figured that it was Germain, a young lady

Figure 7.1: Fig: Portrait of Sophie Germain, circa 1790. Wikipedia

behind the letters. Gauss wrote about her to Wilhelm Olbers saying,

"But when a woman, because of her sex, our customs and prejudices, encounters infinitely many more obstacles than men, in familiarizing herself with their knotty problems, yet overcomes these fetters and penetrates that which is most hidden, she doubtless has the most noble courage, extraordinary talent, and superior genius"

Germain made strides and had a detailed plan of proving Fermat's Last Theorem, during which she stated and proved the Germain Theorem, however her work remained largely unnoticed as 'Lengendre's footnotes' in his publication.

Germain worked throughout her life on several notable topics. A handful of them that still remain at the top of the list are Number Theory, Elasticity Theory, Germain's Prime, Germain's Theorem and specifically, her work on Fermat's Last theorem has brought to light, centuries worth of opportunities for mathematicians to work for in number theory. Rightfully named, she is also known as the *'Princess of Mathematics'*.

Besides mathematics, she had made great efforts in the field of philosophy, aiming to classify facts and generalize them into such laws that could eventually form a system of psychology

and sociology, which at that time, were the emerging fields. Despite receiving the unfortunate news of having breast cancer in 1829, Germain continued to pursue her works among which one of them led to the discovery of the laws of equilibrium and movement of elastic solids, for which she remains largely unappreciated to this day.

Germain remains a name untouched in the history of mathematics, so much so that there is a prize awarded in her name by the Foundation Sophie Germain, conferred by the Academy of Sciences in Paris. This award honors French mathematicians for research in the foundations of mathematics.

Before her death due to breast cancer, Germain was setup to receive an honorary degree from the University of Gottingen, but she never could, because of her untimely and unfortunate demise. She has even published two philosophical papers, besides the disciplines of mathematics and physics.

Her thoughts on algebra and geometry are reflected in this quote by her-

"L'algèbre n'est qu'une géométrie écrite; la géométrie n'est qu'une algèbre figurée."

which translates to-

"Algebra is nothing but geometry, in words; geometry is nothing but algebra, in pictures."

Marie Curie, (1867-34)

Born as Maria Salomea Sklodowska (Manya, as she was affectionately called), in Warsaw, the Kingdom of Poland under the rule of the Russian Empire- she was a Polish born French chemist and physicist who conducted pioneering research on the theory of Radioactivity. She was born during the times when it was hard for the Polish to survive, due to the oppression by the Russians, and even speaking in their native language would have gotten them into trouble of a magnitude which is hard to imagine.

The first woman to win a Nobel Prize, the only person to win a Nobel Prize twice, and the first in the string of the Curie family legacy of five Nobel Prizes, Manya had a fair share of hardships and loss that she dealt with, starting from her childhood, when she lost her mother and elder sister by the age of 10. Her mother had resigned from her position as a teacher at a school that she taught in, after Manya was born. After the loss of two very close members of her family, Manya decided to follow the footsteps of her father who was an atheist and lost her trust in Catholicism and rather developed an agnostic approach towards religion.

Manya graduated with honors from her high school, however she fell into a dark pit of depression, since she had reached the pinnacle of women education during those times in her nation. Her brother went on to pursue medical sciences, however her sister- Bronya and she could not pursue studies any further in their own country, and hence they had become a

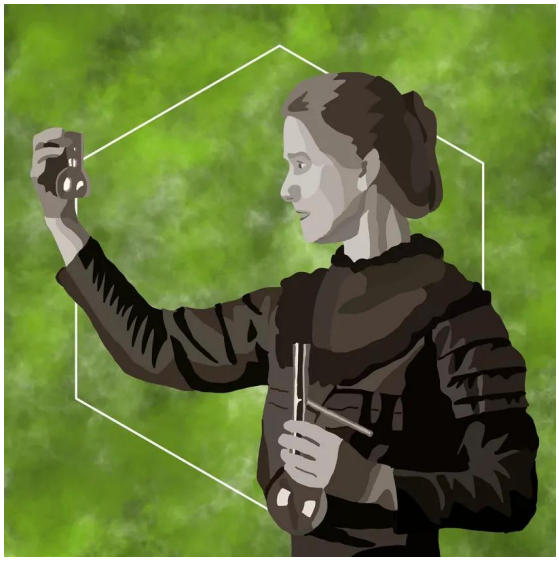

Fig: Marie Curie Courtesy of Sumana Mahata

part of the *Floating University*, also known as the *Flying University* which used to conduct its lectures at different locations, due to it being a group of Polish-born female students, invested deeply into broadening their horizons and voluntarily propagating their learnings. Manya had realized that such a place would not match the teaching standards of the outside academic world, but she was grateful for an experience like this.

Maria and Bronya then moved to France, where Manya, now Marie, tutored to earn an income to support her sister through her graduate school. However, she later realized that the earning from tutoring were not sufficient to support two people, and then she decided to become a governess. While working to try to substantiate the expenses of teaching her sister and surviving in the new city, she fell in love with her neighbor Kazimierz Żorawski, who was destined to be a mathematician. However, the engagement was opposed by his family due to the impoverished earnings of Marie. They broke off the engagement but stayed in contact for a few years, until she left her job as a governess.

After a while, when Marie's father had started earning a stable income, he supported Marie and her sister through their studies, and hence she had now admitted herself in a university to further her education.

Her early days in Paris had shown her a rightful share of her plight, where she studied as hard as she could, sometimes even forgetting to eat and wearing all the clothes she possessed to protect herself from the extreme cold. She would study during the day and tutor in the evening, barely earning enough to stay afloat, even after her father's help. Marie then went on to pursuing a PhD while working in a laboratory, alongside Pierre Curie.

Marie had started working with Pierre Curie in his laboratory through a mutual connection and eventually they established a bond of trust, resulting into fruitful collaborations in academia and a matrimony. Pierre was much elder to Marie and had lost all hope in love, but after a long time of working together, they had mutually established that a bond like theirs had to be kept safe and together.

They had two daughters, and no matter how hard it got for them to manage time, alongside getting help from Curie's parents, he never asked Marie even once to give up on her career, and he has in fact described that the women he met before her, lacked the passion for their work as she had, almost in synchronization with his'.

In fact, Marie had persuaded him to actually write a research paper as his PhD thesis, since Pierre did not possess an actual degree, however he had several research papers under his belt.

Around the time Marie had attained her PhD, the X-rays and the much weaker Uranium rays were discovered. The X-rays caught the eye of the masses, however she was rather interested in the much weaker Uranium rays, for which she went to receive accolades for, in research.

Pierre passed away in an unfortunate incident and after that, Marie isolated herself from the world, to focus just on her works and her children, and she passed away 28 years later after Pierre did.

Maryam Mirzakhani, (1977-17)

Mirzakhani was born in 1977, in Tehran, Iran, during the Iran-Iraq war which ended by the time Mirzakhani turned 8. The endless support from her family in a country with conservative ideas was definitely the catalyst in her life.

Mirzakhani had a knack for solving mathematical problems, she didn't feel interested herself back then, but found it easy to solve the problems assigned to her elder siblings in their mathematics class. After the war ended, she transferred to an all girls school, but the one that was determined to provide the young women with all the necessary catalyzation which will eventually lead them to become the leading youth of tomorrow that will definitely re-define the course of the world, in tiny though profound ways.

Mirzakhani's first year at the new institute was not a comfortable one, however she realized that if she would work hard, she could make a lot of progress, and so she did. She, in the consecutive years, along with her close friend Roya Behesti, qualified for the international team of Iran, to be appearing in the Mathematical Olympiad, and not much to one's surprise, Mirzakhani bagged the gold medal, while Roya, the silver. In the next year too, Mirzakhani became a part of the team and with a perfect score, won another gold medal. She then went on to pursuing her graduation from Sharif University in Tehran, and wrote mathematical papers, while still being an undergrad, needless to say, she went on to bigger and beautiful

Fig: Maryam Mirzakhani at Stanford University. Maryeraud9, Wikipedia

things there on.

Mirzakhani was a PhD Scholar at Harvard, under Curtis McMullen. She thereafter went on to become the first woman ever to win the Fields Medal in 2014, the most prestigious award in mathematics for her work in 'the dynamics and geometry of Riemann surfaces and their moduli spaces'. She has been affiliated in her past with the Clay Institute, and Princeton too. She served as a mathematics professor at Stanford during her last days, where she continued to revolutionize her areas of research until she passed away.

Born and raised in Tehran, her journey has definitely not been a walk in the park, but her passion for Mathematics alongside literature began at a very young age. Mirzakhani as a child thought that she would rather become a writer, due to her keen interest in literature. She became the first Iranian to receive two gold medals and achieve a perfect score in the International Mathematics Olympiad. She described herself as a *'slow'* mathematician, emphasizing that *'you have to spend some energy and effort to see the beauty of math'*.

Her daughter described her mother's works as 'painting', which was Mirzakhani drawing *doodles* of hyperbolic surfaces on a blank sheet of paper.

Mirzakhnai was diagnosed with breast cancer, a year before she received the Fields Medal, and she passed away three years after in 2017. She however, lives timelessly in the minds and hearts of the people whom she inspired, simply by her presence and aura.