Jiddi

THE ZEALOUS ONES

Dr. Sulabha Kashinath Kulkarni

Indian National Science Academy
New Delhi

AN ODE TO FEARLESS WOMEN

Defined by no man, you are your own story,
blazing through the world, turning history into herstory.

And when they dare to tell you about
all the things you cannot be,
you smile and tell them,
"I am both war and woman and you cannot stop me"

– Nikita Gill

Jiddi

THE ZEALOUS ONES

Genius Women Scientists
who
Broke the Barriers

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Foreword

One of the core components of sustainable development goals is gender equality. Gender equality in science is all the more important because it brings in diversity, essential for modern-day science to succeed. Mobilizing women for scientific endeavors is essential to attain technology-led economic growth. During the last 20 years or so, there has been an increase in the participation of women in science in the country. Having said that I would reiterate that there is still a gender disparity due to a complex set of reasons. Persistent challenges remain.

Many of the reasons for not enough women coming forward are linked to society, facilities in scientific organizations, lack of encouragement to go into science by family and teachers, and many others. One of the issues that women face, particularly younger women entering college is the absence of exposure to role models. It is required that stories be told about scientists who happened to be women and how their journeys were. This is an important step to motivate the young mind. Exposure to scientists' lives in one's own country and the rest of the world is important.

This book sketches the lives of several brave women who navigated many obstacles to achieve their goals. The younger generation will enjoy the achievements of women who have contributed much to the shaping of present-day science. Each life sketch in this book details inspiring stories of women who are role models in their own right. All these women shared one trait, they were fighters and scaled all odds to succeed.

There is a long way to go to achieve gender parity. The idea is to enthuse women who are at the beginning of their careers to enter into science and contribute while enjoying it. It is not easy to tell stories spanning a large period of time but it can be challenging and instructive. This book will be appreciated by students who are looking for a career in science.

The Indian National Science Academy strongly feels that young women should be encouraged to enter into the scientific endeavor of the country. Young women must get motivated by crossing the slow pace of social change to evolve into encouraging a girl child to join the science stream of education. It is our small effort towards that goal through this book.

INSA is striving diligently to encourage entry of women at all levels. It feels eminently convinced that their participation in large numbers will be the key to scientific progress and towards developing scientific tempers.

Place: New Delhi
Date: 2nd December 2022

Chandrima Shaha
President
Indian National Science Academy

Preface

When one asks 'who are the great scientists?' To anyone's mind come Einstein, Newton and Raman. At the most Edison, Louis Pasteur or Abdul Kalam, all the male scientists! When asked if there are women scientists? Marie Curie is remembered! Very few would go beyond these names! This is not surprising. Indeed until the middle of twentieth century very few women in any part of the world had access to education, forget about doing research. It was considered to be men's world (privilege?). Moreover, most of the population was deprived of education and hardly small percentage of men received education and had access to laboratories. In such circumstances it was very difficult for women to get an opportunity to get education. Moreover, in the conservative societies, women's opinion was not taken into account in any major decision. The social expectation was that women should remain content in the walls of the house and care for the family. Where was the need for women's education? Even some men and women were easily convinced by the arguments like higher education would affect women's minds and fertility! Such arguments were baseless as proved by some illustrious women scientists whose contributions to science were not given enough publicity. They were in a way kept in the dark. Some historians are trying to unveil the contributions of women scientists.

If we accept that Science is driven by curiosity, we also have to accept that it is not bound by place, time, country, caste, creed, religion or gender. There are couple of famous women scientists like Marie Curie or Lise Meitner but there are many others whose struggle, ingenuity, dedication, originality would not only be inspirational to women but also men. Recently few books revealed struggle of some women scientists. However, female scientists from India are hardly covered. Their struggles and achievements are at par with many famous scientists. Today in many parts of the world women are working in many fields shoulder to shoulder with men, it must be remembered how this has been possible. When young student Kamala Sohonie took the challenge of hard work and excellent research in one year, girls started getting a chance to get admitted (1934) to Indian Institute of Science, Bengaluru, India. Even before that Sofya Kovalevsky (1850-1891) a Russian woman had pretended to have married and escaped to Germany to learn

university level mathematics. Sofya was driven by her love for mathematics and became the first female professor in Europe. Rakhmabai Raut (1864-1955), an Indian doctor, had difficulty becoming a doctor due to her marriage in childhood. She had to give an unprecedented legal as well as public fight.

All know that Marie Curie left her country due to her innate urge for science. Her name has become immortal because of her unique contributions to science and the hardships she has gone through. She was rightly rewarded by the highest award in Science viz. Nobel Prize and recognition. But many women before and after Marie Curie, also struggled to get high education in science, and significantly contributed in their own way but did not get enough recognition.

Hypatia (350-415 AD) from Egypt, historically the first woman to study and teach astronomy and mathematics, was beat by some fanatics to death. Zhenyi Wang of China (1768-1797) died at the age of 29, but left her impression on mathematics and astronomy of China. Very few people know the contribution to statistics made by Florence Nightingale (1820-1910), a well-known British nurse from a wealthy family. Similarly Ada Lovelace (1815-1852), a woman from a noble family in England, wrote the first computer algorithm and suggested the possibility of a robot. Coming out of their happy lives, the work done by some of these women, no less than men, should be known to all!

Agnes Pockels (1862-1935), observed the floating soap bubbles on water while washing dishes in the kitchen. Women were not admitted to university and she had to take care of her sick parents at home! She made the first surface tension measurements devising an apparatus using household components and laid the foundations of a branch known as Surface Science. It is not just important in physics and chemistry but even in biology. Perhaps because of her lack of higher education, she was not well known in the scientific circles and was deprived of the Nobel Prize. There are some other great female scientists also who missed the Nobel Prize, sometimes because of being a woman, sometimes as a victim of the political situation and sometimes as a victim of the politics of their colleagues. Lise Meitner (1878-1968) was one such great scientist.

There is no shortage of female scientists who significantly added value to science. They had to often oppose, rebel against family or society but they were highly focused and did not deviate from their chosen path! Émilie du Châtelet (1706-1749), a French woman, married, young mother, used to go to a restaurant in Paris disguised as a man just to attend scientific discussions! She also worked hard to complete her contribution until her early death. Rita Levi-Montalcini

(1909-2012), an Italian Jewish woman needed for the experiments, certain rats. She smuggled them on a flight between U.S. and Mexico in her purse!

In the late 19th century, worldwide women had hardly begun to attend the lectures at universities with great difficulty and then formally begun to get admission. India was a part of British Empire from 1600 to 1947. Most of the population was uneducated and hardly few men received higher education. In such circumstances it was very difficult for women to get an education. Moreover, the social expectation was that women should remain content in raising the children and take care of the joint family. What was the need of educating women? But, not all men thought like this. There were some social reformers, individuals as well as organizations. Due to their efforts in India Anandibai Joshee (1865-1887) and Kamalini Ganguly became doctors.

This book, narrates 28 adventurous and inspiring women who carved their own path through their contributions to science and education. When I came to know the biographies of these great women scientists myself, I asked where did they get all this energy? They did not give up science even in the most adverse circumstances. Even today, many have to deal with personal or social adversities.

If anyone is inspired by any of the biographies in this book or becomes aware of the struggles of women scientists, then the purpose of writing this book is fulfilled! This book can be considered as the tip of the iceberg! Unfortunately it was not possible to cover the contributions of many other deserving female scientists including the currently active women.

S. K. Kulkarni

Pune, Maharashtra SULABHA K. KULKARNI

Date: 2nd December 2022

Ackowledgement

With great pleasure I would like to thank Dr. A.K. Singhvi, former Vice-President of INSA who after seeing my book "Jiddi" in Marathi had suggested me to approach the President of INSA, Dr. Chandrima Shaha, in order to seek the possibility of publishing in English. I am grateful to Dr. Shaha also for writing the Foreword and critically making useful comments to this book. My thanks are also due to Professor Amit Ghosh, Vice-President, INSA; Dr. Vinay Arora; Dr. Seema Mandal and Sci-Soc section of INSA as well as thefinancial support by INSA.

I had submitted the text and the sketches to Angkor Publishers. When I received the first proof of the book, I was quite stunned to see the layout quality of print (even in e-print), the added photographs and some of the quotations, besides the painstaking but meticulously carried out editing work. It was a great satisfaction to me that Ms. Manisha Shrivastava, Director of Angkor Publishers (P) Ltd. and her team had taken so much of initiative to make the book beautiful. Thanks Angkor Publishers for taking deep interest in the work you do!

Publishers of the Marathi version of Jiddi, Mrs. Smita Deshpande and Mr. Sagar Deshpande of Sahyadri Prakashan are acknowledged for their kind support. I take this opportunity to thank Dr. Shakuntala Nene for translating the book in Gujarathi.

Originally I had written the book 'Jiddi' in Marathi, wherein brief biographies of 26 women scientists were given. The name 'Jiddi' was suggested by my husband Mr. K.D. Kulkarni. He voluntarily offered some sketches for the book which made it live. I take this opportunity to thank him for his interest and contribution. My family members Aparna Madhekar, Neeraj Madhekar (son-in-law), Lt. Col. Nikhil Kulkarni and daughter-in-law Geetanjali Kulkarni are thanked for always standing by me. Special thanks are due to my grandson and budding scientist Mukul Madhekar for going through the initial English draft and making useful suggestions. Last but not the least, the younger grandson Manas Madhekar is also thanked for his enthusiasm and cheerfulness about the book. His company has always added spice to life.

SULABHA K. KULKARNI

Hypatia

The World's First Female Astronomer and Mathematician

(~ 350 – 415 AD)

Hypatia who was well known as a great philosopher is likely to be the first woman in the world to learn and teach astronomy and mathematics. She developed Astrolabe—a device used to determine the position of the sun and stars. She also did some basic research in geometry and statistics. Hypatia lived in the city of Alexandria in Egypt. Unfortunately, Egypt witnessed frequent riots between Jews, Pagans, and Christians. Being a worshipper of Greek deities, she was brutally murdered by some fanatic political Christians.

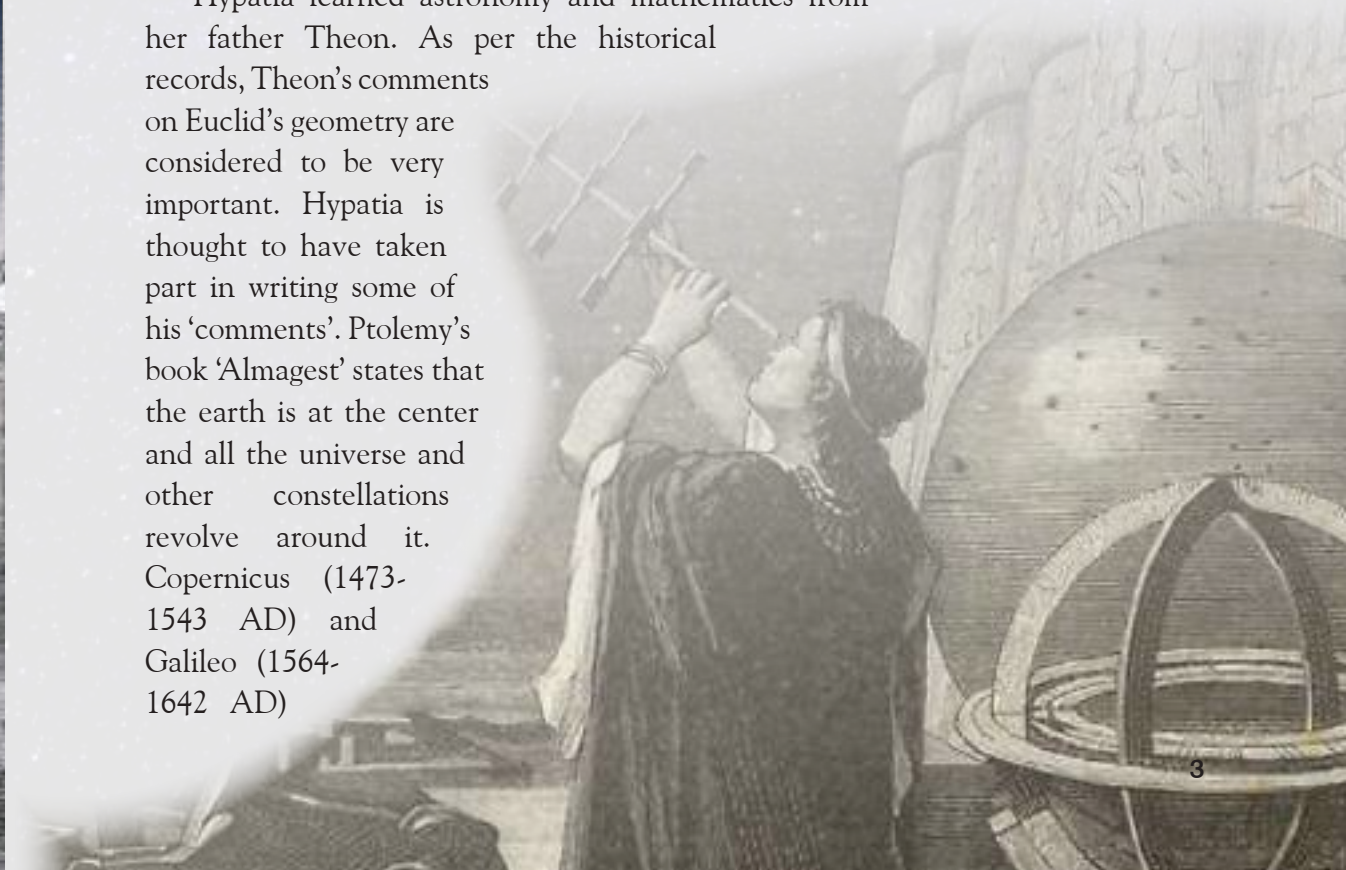
CHAPTER ONE

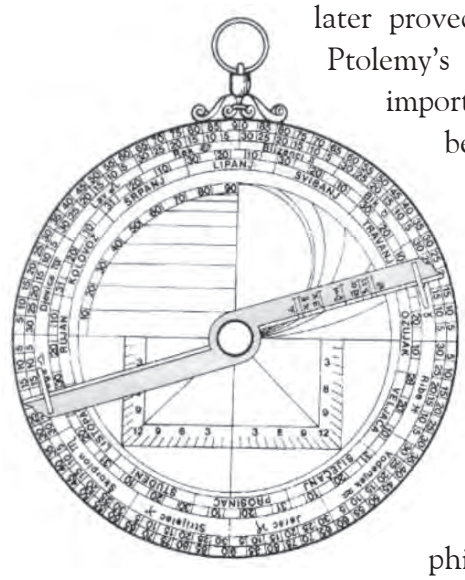
Hypatia – The intellectual stoned to death

In 331 BCE, the Greek emperor Alexander the Great conquered a town in Egypt and founded a city called Alexandria. It was an important and thriving city of Greek and Roman culture for about 1000 years. It was also the capital of ancient Egypt for many centuries. Lot of wealthy merchants used to come there for trade. Situated on the shores of the Mediterranean Sea, the city was famous for its ancient lighthouses and state-of-the-art library. Handwritten texts on papyrus mutely narrate the rich cultural history of the city. The enormous treasure of books numbering between 40,000 to 400,000 were a great attraction for philosophers and scholars. At the same time Alexandria was the home of scholars as well as traders who were fascinated by Alexandria's cultural and intellectual environment.

Hypatia was the only daughter of Theon (around 335 to 405 AD) who was a famous Alexandrian philosopher and mathematician. She was born in Athens, Greece. Historians differ on the date of her birth, but she was probably born between 350 and 360 AD. Perhaps she also had a brother named Epiphanius. He may also have been a disciple of Theon. There is no information available about her mother. There is no doubt that Hypatia remained unmarried throughout her life. This could be due to the strong influence of Plato's ideas which did not believe in or approve of the family system!

Hypatia learned astronomy and mathematics from her father Theon. As per the historical records, Theon's comments on Euclid's geometry are considered to be very important. Hypatia is thought to have taken part in writing some of his 'comments'. Ptolemy's book 'Almagest' states that the earth is at the center and all the universe and other constellations revolve around it. Copernicus (1473-1543 AD) and Galileo (1564-1642 AD)





later proved it to be wrong. Theon's third edition of Ptolemy's Almagest was considered until then an important book on astronomy. Some historians believe that the Almagest's third edition must have been actually written by Hypatia.

Hypatia was a very intelligent and beautiful woman. She was well versed in philosophy, astronomy and mathematics. She never had any difficulty in freely talking or moving in Alexandria and she was equally at ease in participating in discussion sessions in the city. She was an authoritative person to talk on Plato's philosophy. Therefore, despite being a woman, she was welcomed to participate in seminars. She loved to teach astronomy and mathematics. She was admired by scholars for her easy-going demeanor, attractive appearance, extraordinary intelligence, as well as her excellent personality. People would come from far away places to hear her thoughts and to discuss with her. She had many disciples of her own. A letter from one of her students, Synesius, mentions that an astrolabe (an astronomical, easy-to-carry portable device for determining the position of the sun and the stars) was made by Hypatia. It is possible that she may not be the inventor of astrolabe, yet, it does signify that Hypatia was able to develop her own 'device' at that time. This device (astrolabe) was used even in the 19th century.

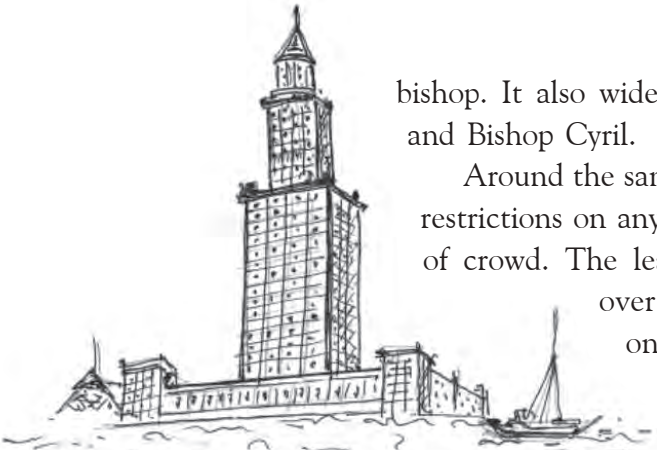
Orestes, the governor of the city of Alexandria in those days, consulted Hypatia frequently. Much to the dislike to several people, he used to respect and treat her very well. The city of Alexandria was inhabited by Jews, Christians and Pagans, who constantly had rivalry between themselves on issues of religion. Hypatia too was a Pagan. She was brutally murdered in one such riot in 415 AD. Well known as an expert of astronomy, mathematics, science, philosophy and a scholarly

> **"In fact men will fight for a superstition quite as quickly as for a living truth — often more so, since a superstition is so intangible you cannot get at it to refute it, but truth is a point of view, and so is changeable."**
>
> – *Hypatia*

woman, just because Hypatia was a Pagan, she was killed by fanatics who believed that she was a witch, practicing witchcraft! More stories have been written about her death than those during her lifespan. The reason is the dramatic events that took place during the riots!

> **Was not Hypatia the greatest philosopher of Alexandria, and a true martyr to the old values of learning? She was torn to pieces by a mob of incensed Christians not because she was a woman, but because her learning was so profound, her skills at dialectic so extensive that she reduced all who queried her to embarrassed silence. They could not argue with her, so they murdered her.**
>
> *– Iain Pears, Art Historian*

Various theories have been propagated about the exact reason of Hypatia's death. Probably her increasing popularity owing to knowledge resulted in jealousy which could have been the reason behind Hypatia's murder. Especially good rapport among Orestes and Hypatia was disapproved by the Christian clergies because they perceived it as a threat to their diminishing popularity in the society. The Easter festival of the Christians and the Jewish festival are determined by the equinox, when the length of the day and the night are same. The equinox day falls on March 21 or 22. Easter is celebrated on the first Sunday after the equinox day. Therefore, it was important to decide exactly when the day and night were the same. Since Hypatia had good knowledge of astronomy, Orestes had sought her help for this purpose. Hypatia's decision did not go unnoticed by Cyril, then a Christian



bishop. It also widened the gap between Governor Orestes and Bishop Cyril.

Around the same time, Orestes issued a notice imposing restrictions on any dance or music programs and gathering of crowd. The leaflets to this effect were distributed all over the city. A large crowd had gathered at one place to read it. The decree created a huge dissatisfaction among Christians as well as Jews. Cyril sent one of his trusted colleagues, Hirax, to see what the decree was about. Hirax himself was not really against the decree. But many thought that he was provoking people. When Orestes came to know about this rumor, he ordered Hirax to be captured, tortured and killed in public. This made Cyril and other Christians very angry and Cyril appealed to the Christians not to spare the Jews either. As a consequence the situation became chaotic and fights broke out between Jews and Christians. At the same time, some Christians came to believe that Orestes was a Pagan. In fact, he was a Christian. The people did not stop attacking Orestes and his chariot. Christians got a chance to take a revenge from Pagans. Hypatia was actually a Pagan. The angry mob attacked her when she was on her way home from her university lecture. She was pulled out of her chariot, stripped naked, and tortured to death and finally burned. A very painful death fell on Hypatia. Hypatia's death was unfortunate, but after this incidence Alexandria's splendor also began to wane.

Historians believe that Alexandria's wealthy library was destroyed in these riots, and that the ancient culture of Alexandria also disappeared with Hypatia. Slowly by the 14th century, Alexandria's famous library and lighthouses were destroyed, and what was left collapsed in an earthquake. In many countries dramas were staged and bio-pics made in different languages that portrayed Hypatia's life. The main reason was the ghastly end of the most erudite, unique and beautiful young woman of that time!

> **Reserve your right to think. For even to think wrongly is better than not to think at all.**
>
> *– Hypatia*

Maria Sibylla Merian

A New Direction in Biology....

(2 April 1647 – 13 January 1717)

Maria Sibylla Merian studied the entire life cycle of insects and bugs when they were only seen as disgusting creatures. She observed how the metamorphosis took place starting with eggs laid on the leaves of trees, larvae, caterpillars, and then butterflies. Maria studied 186 species of insects and discovered some new species. Not only that, her beautiful watercolor paintings showed the world a new direction in the study of zoology. Isn't it amazing that during the late 17th century and early 18th century, a European woman went to the jungles of South America alone and carried out such work?

CHAPTER TWO

Maria Sibylla Merian was born in the Merian family, the founder of the famous 17th century publishing house. Maria was born on April 2, 1647, in Frankfurt, Germany. Her father died when she was 2-3 years old. Her mother remarried Jacob Merrell who was a painter. He encouraged Maria to paint. Since childhood she began to draw beautiful pictures. She also began to imitate her father, especially by collecting flowers, leaves, and insects from the garden and observing how he was drawing pictures. She developed a liking towards nature.

In 1665 Maria married Andreas Graf, a follower of Jacob Merrell. Three years later they had a daughter. They all left Frankfurt in 1670 and settled in Nuremberg, the German hometown of Andreas Graf. In 1678 they had another daughter. They lived in Nuremberg for14 years. Maria's hobby of observing nature was well nurtured here. She also started taking painting classes for young girls of wealthy families in Nuremberg, with the aim of helping the family financially as well as enjoying it. The added advantage was that she got an opportunity to visit well maintained gardens of affluent people. It was as if her nature-obsessed attitude got fertilized. Maria drew beautiful watercolors of flowers in and around Nuremberg, and wrote three books of paintings on flowers between 1675 and 1680.

All of Maria's books and pictures were in watercolors. Sometimes she even made engravings of flowers and insects. However, she did not make oil paintings. This is because of the 'guild' system that existed in Europe at that time. According to the rules of the system, no artist could draw or sell oil paintings independently. There were some established members of different guild groups. They had worked for a long time and had the right to decide what to paint and what to sell! Until the 18th century, women did not participate in the guild. So Maria had to settle for painting with watercolors. Maria is a perfect example of how to find a way or overcome the hurdles and keep on working!

In 1678 Maria returned to Frankfurt along with her husband and two daughters. Her two

books on insects were published in 1679. She had included in the books the paintings on metamorphosis of the insects, which made the books very attractive and informative. The illustrative books on insects were novel and the first of their kind. In 1681 her father Jacob Merrell died. In 1683 Maria moved with her husband, two daughters and mother to West Friesland. Friesland is now in Netherlands. There they lived amongst a community of Labadists. Maria liked their thoughts but her husband could not adjust with their lifestyle and left forever, though he returned a couple of times! The rules of the Labadist community were rather strict and most of the people could not live there for long. Maria could spend some time there on natural history and Latin. She also collected various insects. But Maria shifted in 1691 with her younger daughter to Amsterdam for good. Her elder daughter got married in the same year. Maria's mother had already died in 1690. In 1692 Maria legally separated from her husband.

During 1675 to 1680 Maria had already published books on insects with beautiful drawings. Instead of scientific Latin language she used very simple language, which could be understood by common people. Although scientists neglected her books, she became very popular among layman. Slowly the scientists also had to take her writing and work seriously. In those days it was very popular to collect dead insects and preserve them. But studying metamorphosis of insects was not an easy task!

In Amsterdam, Maria got an opportunity to see some of the city's elite collections of rare insects. These were dead insects from the East or West Indies. Maria was amazed at their variety, shapes and colors. She was familiar with the insects from Europe but she realized that there was a bigger world beyond it! At the same time, she realized that there was no information regarding the plants these insects lay their eggs on, how they turn into larvae and caterpillars, and in

> **"Art and nature shall always be wrestling until they eventually conquer one another so that the victory is the same stroke and line: that which is conquered, conquers at the same time."**
>
> *– Maria Sibylla Merian*

how much time they do it, what they eat, how long they live etc.. Maria realized that there was no information available and thought that she herself should go to South America and study it.

In 1699, the city of Amsterdam allowed her to move to Suriname in South America, with her youngest daughter for five years, to study entomology. There was a Dutch colony in Suriname. Maria was the first woman to go abroad for research work, without being accompanied by a man. Maria sold 255 of her paintings for her travel expenses. On July 10, 1699, Maria boarded a ship with her youngest daughter to go to Suriname. She arrived in Suriname on September 18-19, two months later. There she immediately began her research work. Accompanied by her daughter in the wilderness, she saw new species of insects, snakes, frogs, spiders and plants. Their impressions (engravings) and paintings in watercolor made by her displayed her creativity and artistic sense. When many of the male scientists did not go deep and study what were considered to be 'petty' animals, Maria Sibylla Merian worked tirelessly to find a new direction for the study of animals and plants. It must have been very difficult to move in the forests and that too in a foreign land. There could have been problems with food, language and various others issues, but the brave and curious woman Maria overcame everything until she fell prey to malaria infection and had to return to Amsterdam in June 1701. In 1705, Maria's book on insects in Suriname was published. In 1715 she had a stroke. However, she continued working till her death. On 13th January, 1717 she breathed her last in Amsterdam.

After Maria's death, her daughter published her work. Peter-I, Czar of Russia bought many of Maria's paintings. Maria's work was re-evaluated and republished in the late 20th century. Maria's scientific approach is well acknowledged by today's scientists. Her portrait was printed on a postage stamp of 500 Deutschmark (pre-euro German currency) and 0.4 Deutschmark. In 2005, a German ship was named after her. On April 2, 2013, Maria's 366th birthday was celebrated by Google Doodle. Her paintings have been used by many music artists, such as Mozart, on albums or in the magazines of their events. Most recently, in 2016, her work on insects was republished. In June 2017, a seminar was held in her honor in Amsterdam. Maria's work is timeless and a beautiful fusion of science and art.

Google doodle in honour of Émilie du Châtelet

Émilie du Châtelet

SCIENCE TILL THE LAST BREATH...

(1706 – 1749)

Born in an aristocratic family, Émilie du Châtelet learned to read and write a little bit at home as was the custom at the time. Her father noticed her love for science in her childhood. But her mother was strongly opposed to Émilie's learning. Education of a girl from a wealthy and reputed family like hers and that too subjects like mathematics or science was a matter of surprise at the time! But no matter how much one is pressed, how long can one's intense desire be suppressed? Married at an early age, educated at home after having children, Émilie's contribution to science, especially French science, is incomparable. She completed her last writing just eight days before giving birth to her fourth child – a baby girl, bidding goodbye to this world.

CHAPTER THREE

In the frontispiece to Voltaire's book – Voltaire traduisant les écrits de Newton, *Émilie du Châtelet holds the mirror, which refers to her role as translator of Newton's writings.*

Émilie du Châtelet was born on December 17, 1706, in Paris, the capital city of France. Émilie du Châtelet is her name after the marriage. Her father's name was Louis Nicolo le Tonnelier de Bretouil and her mother's name was Gabriel. She had five brothers. Except for one brother, the other four died at a very young age. Émilie's father held a high position in the royal court, and so Émilie also moved in high society since her youth. Her family had a prestigious place in social circles.

In spite of being tall Émilie was very ordinary looking. When she was about 10 years old, her father became aware of her extraordinary intelligence. So he appointed a teacher at home to teach her Latin, Greek, Italian and German. Thus, only at the age of 12 Émilie began to speak all these languages fluently. She could do horse riding and swordsmanship, as was the custom in the rich families at that time! Seeing her inclination to astronomy, her father used to call Fontenelle, the secretary of the French Academy of Sciences, to discuss the scientific matter with her. She was also making good progress in dance and acting. As a result, she became very 'modern' compared to other girls of her age.

From the age of 16, Émilie became accustomed to mingling with the royal court people. She loved expensive things, diamonds, perfumes and expensive clothes. But at the same time, her discussions on philosophy, literature, and astronomy with a select few did not diminish. She loved to participate in the intellectual discussions. Nonsense gossip or tingle and rumor did not interest her. She did not like such a company of rich women. Her mature, studious thoughts would automatically keep her away from rich people. She felt a sense of emptiness in their conversation. As a result, she did not have many friends. This behavior of hers did not suit the daughter of a rich and noble family. Seeing all this, her mother was terrified. She was worried, as to how to keep her daughter away from education and confine her to the manners of the society. Émilie's father and mother often argued over Émilie's education. The quarrel finally ended on June 12, 1725, after Émilie's marriage. At just 18 years of age, Émilie was married off to a much older man, a 34-year-old noble man.

On the occasion of their marriage, Émilie's father presented her husband with the title of 'Governor' in Burgundy as a 'gift'. After the marriage Émilie became Émilie du Châtelet. In September 1725, the newly weds moved to Burgundy. They had 3 children in 7 years. But one of the boys died as a child.

Chapter 14 on the phenomena of gravity has a picture of a device used to demonstrate Galileo's law of natural motion. The paraboloid apparatus involves dropping balls on a spiral track to show that each turn of the spiral is traveled in the same amount of time (isochronism).

– Émilie du Châtelet's Institutions de Physique

Émilie and her husband had very different temperaments. She loved the urban atmosphere of Paris; but her husband an officer in the army had a hobby of wandering in the forest and hunting! He did not mind her ways or doing what she liked. At that time in France, the separation or free behavior of the husband and wife from an upper rich family was not uncommon!

By the age of 26, Émilie's love for science would not let her sit quiet! When she became interested in Newton's work, her friend Richelieu advised her to study advanced mathematics to understand Newton's theory. For this she requested Moreau de Maupertuis to teach her. Maupertuis was a member of the French Academy of Sciences. He knew astronomy and physics. He had learned from John Bernoulli.

'Newton's theory' was a hot topic in physics at the time. Every Wednesday The French Academy of Sciences used to have its meetings in which many new topics in science were discussed. Émilie wanted to participate in it. But when women did not even have access to school or university at that time, it would have been impossible for Émilie to get admission in an academy, where even select scientists also could hardly get admission! But Émilie was ready to quench her thirst for science discussions in an alternative manner. Maupertuis and his science group friends used to meet at Gardot's coffee house. Many philosophers and mathematicians also gathered there and discussed science. Émilie decided to join their science discussion group. But even there, women were not allowed! That's when Émilie decided to play a trick! She started going there in men's attire! The owner of Gardot coffee house noticed this but he decided to ignore it. This was going on with Maupertuis's knowledge. The owner too did not want to let go away his usual customers by arguing on it. So Émilie's intellectual thirst was somewhat quenched!

Later, in 1735, Émilie received her guidance in mathematics from the famous mathematician Alexis Clarot. She studied geometry, calculus, algebra and physics, as much as possible at that time. From both Newton's theory and

mathematics her view of looking at the world around her had changed. Her new study helped her to understand the scientific meaning of seemingly insignificant phenomena in nature. It was like a divine experience! She was overjoyed to learn how strong the wind must be to move the branches of a tree, the science of birds' flights can be understood through mathematics and science. She started trying to apply her new knowledge everywhere and understand how the things work. She also liked to sometimes translate literature and philosophy from other languages into French. She used to spend nearly 12 hours a day on reading and writing. It was all for the sake of love for science and not for any prize or fame!

> **"If I were king, I would redress an abuse which cuts back, as it were, one half of human kind. I would have women participate in all human rights, especially those of the mind."**
>
> *– Émilie du Châtelet*

Yet, in order to test her own ability, Émilie submitted an anonymous research paper for a competition at the French Academy of Sciences. Just two weeks before the competition, she took the decision to send an essay. Her essay was on light, heat and fire. In it she described in detail the nature of infrared rays and light. She discussed how the color of light changes with heat. She did not receive the award, but was described as a good essay sent by an unknown woman, and was published. Of course, many thought that it was Émilie's paper, because there was no other woman than Émilie who had so much scientific background!

In 1740, Émilie's book, 'Lessons in Physics', was published in French. Her main purpose in writing such a book was to teach physics to her 13-year-old son. In this book, she tried to explain the ideas of the leading scientists like Newton, Lebanese and Cartesian in a coherent way and simple language. Shortly after that, in 1741, Dortus de Myron, secretary of the Royal French Academy, criticized the book. Myron targeted her book mainly because the author of the book was a woman! He alleged that women's intelligence was basically weak. He further said that Émilie also was mentally weak and she did not understand mathematics and science. He indicated that she was not capable to understand Newton's theories. After reading this, Émilie decided not to keep quiet. In response to his criticism, Émilie refuted each of Myron's points and sent copies of it to all members of the academy. By her pin-pointed and accurate writing the members of the Academy were convinced about her work. As a result, Dortus

> **Let us choose for ourselves our path in life and let us try to strew it with flowers.**
>
> – *Émilie du Châtelet*

de Myron himself had to resign as the secretary of the academy. Not only this, in 1746, Émilie, was made an honorary member of the Academy of Sciences by the Institute of Bologna. Thus, Émilie received her due place in the circle of scientists.

Later, Émilie opened the doors of her home in Cirey about 150 miles east of Paris, to scientists and scholars. She enthusiastically invited those who wanted to do some research work or have discussions to stay there any time. So many scientists and philosophers kept coming there, held meeting and quietly did their research work. But Émilie's greatest contribution was the French translation of Newton's famous book, 'Principia'. The book, written by Newton in 1667, continued to be important for the next three centuries. It is a treatise on the motions and energy, theories of planets and stars in the sky, as well as small and large objects on the earth. Newton's three well-known laws of motion are also described in this book. The translation in French by Émilie was the result of her constant work. Unfortunately it turned out to be her last work. In a row for 4 years she had focused on this work. One might think that translation is not someone's new or original work. But this translation is not just a literal translation but her own comments contained in it. More information was added almost everywhere, explaining the meaning. In addition to the translation, it contains 287 pages of appendix or supplementary writing.

Émilie must have realized that her end was near. As a result, she continued to work even during pregnancy until the end of her life at 42. She was working day and night for 16-17 hours a day with the determination to finish her undertaken work before giving birth to a child. Sometimes she was working till 5 O'clock in the morning. She used to dip her feet in very cold water to keep herself awake when she could not control the sleep. Finally, just eight days before the delivery, the French translation of Newton's Principia was finished. She died shortly after the delivery on September 10, 1749, at the age of 42. So there was a talk everywhere that France had lost a great scientist. Her French translation of the Principia was published after her death in 1749. It became a very important book for French scientists.

Émilie was well ahead of her time. Her writings on philosophy, religion and literature were considered to be a treasure trove of ideas and knowledge. She also used to talk wherever possible on women's education. She felt that keeping women away from education was like inflicting a great harm on science and literature.

Zhenyi Wang

Master of All

(1768 – 1797)

In the 18th century in China, when women were not even allowed to learn, Zhenyi Wang learnt at home. Zhenyi was able to learn mathematics and astronomy through the books collected by her grandfather and father. On the strength of her independent and rational thinking, she expressed her views on eclipses. Through her poems she spoke out against the then feudalism in China. She also raised her voice in favour of equal rights for men and women.

CHAPTER FOUR

Zhenyi Wang was born in 1768 in her ancestral home in Anhui Province in Jiangning or present-day Nanjing which was ruled by Qing dynasty at that time.

Due to the feudal system there were only two types of people, those who were extremely rich or those who were poor. Women were considered a different and still a lower class! They were not provided education nor enjoyed any rights. Only the feudal lords and wealthy men were in the best condition. The plight of the poor was terrible, beyond words. Zhenyi Wang, however, was lucky. Her childhood was spent with her grandparents and father who were very rich, liberal and progressive.

Zhenyi's Grandfather – Wang Zefu was the Governor of Fengchen Province and Zhuanhua District. But most importantly, he was very intelligent and liberal. He loved reading. In those days he had a collection of 75 books or a small library in his own house, which was a big deal. Zhenyi's grandfather taught her to read and write. Therefore for little Zhenyi being close to grandfather's books was like possessing a big treasure. Although at that time women's education in China was not prevalent, still due to the liberal thinking of her grandfather Zhenyi got an opportunity to learn at home. The atmosphere at home was such that in the house everyone was eager to teach her.

Zhenyi's grandfather was a scholar as well as teacher of astronomy. Therefore, he also taught her elementary lessons of astronomy. This instilled in her curiosity and interest in astronomy. She also inherited from her grandmother Dang the knack of composing poetry. Her father was a medical expert. He had published four books on medicine. He not only taught Zhenyi mathematics and geography but also introduced the subject of medicine to her.

Zhenyi's grandfather died in 1782 when she was 14 years old and the family shifted to Jilling. They stayed there for about 5 years. Jilling is near the Great Wall of China – one of the 7 wonders of the world. There, Zhenyi got an opportunity to read a lot from her grandfather's books. A Mongolian General's wife named 'Aa' taught Zhenyi horse riding, archery and Kung-Fu. In China, the famous martial art of Kung-Fu was originally created for self-defense. At the young age of 16-17 years

> **When talking about learning and sciences, people thought of no women (...) [People say that] women should only do cooking and sewing, and they should not be bothered about writing articles for publication, studying history, composing poetry or doing calligraphy. (...) [Me and women] are all people, who have the same reason for studying.**
>
> – *Zhenyi Wang*

Zhenyi became an expert in this art. She became famous as an extraordinary person at a very young age due to her education, expertise and all round personality.

Besides Zhenyi's education and upbringing the additional reason for her accomplishment was that she was only 16 years' old when she walked with her father a lot south of Yangtze River. Therefore, her knowledge of geography of China as well as the understanding of the political and social situations and observations of China became extremely remarkable. In her poems, she describes the gap between the rich and the poor. In one of her poems she wrote that 'from some village kitchen smoke does not come out and insects infest the grain in the rooms of the rich and grain is wasted.' At one point, she says, girls also want to learn like boys and are equally intelligent as boys. She thought and expressed that, men and women should have equal rights. She also used to preach such thoughts.

Owing to her poetry, Zhenyi came in the contact with many intelligent and scholarly women. Zhenyi got married at the age of 25. Her life was happy with Zhen Mai from Zhucheng village in the province. But her love of mathematics and astronomy did not diminish. Her studies and research continued even after marriage. She thought that even though the earth is round, we and other animals do not fall which may be related to gravity. People at that time believed that eclipses occurred due to some divine wrath. This belief was so deep-rooted in the mindset of people that they could not think that there could be any scientific reason for solar eclipse or lunar eclipse. Zhenyi however being a great thinker did not believe in the concept of divine wrath. She thought that there could be a scientific reason for the eclipses. In the absence of proper explanation or laboratory of modern times, she decided to mimic an eclipse in her own house. In her garden pavilion she set up a round table to represent the earth, a lamp to represent the Sun and a round mirror for the moon. She aligned them and

changed their positions and explained correctly how the eclipses occurred. Her finding was published in an article 'The Explanation of a Solar Eclipse'.

Zhenyi loved the accuracy of the Western calendar. Chinese people did not like it because it was a foreign piece of knowledge. As it was correct and useful Zhenyi was of the opinion that it should be accepted without any bias. She was obsessed with mathematics, especially geometry of Pythagoras. She had also analyzed the right angle triangle and accurately described the relation between its sides. Apart from that she presented many mathematical theorems in a simple way which were also published. The literary language in those days was difficult to understand by common people, therefore, she used to write in a simple and lucid manner which could be easily understood.

A book entitled 'Principles of Calculus' written by the famous Chinese mathematician Mai Vending (1633-1721 AD) although very useful yet was very complicated. Zhenyi studied the book thoroughly and presented it in a very simple manner so that it could be used by lot of people. She also devised some simplified methods of division and multiplication, which were useful to many people. Thus, Zhenyi made major contributions to the mathematics and astronomy of the time.

Zhenyi Wang lived only 29 years. She died in 1797. She taught mathematics to some boys as well as girls. She had many students. As soon as she realized that her death was nearing, Zhenyi handed over all her writings to her best friend Madam Cui. She in turn gave those to her nephew, Quinn Yiji (1783-1850) who was a famous scholar. He put it together neatly and properly published it.

Qian Yiji was very impressed with Zhenyi Wang's work. He once said that Zhenyi was the most talented and influential female scholar after Ben Zhao who lived from the year 45 A.D. to 116 A.D. and became very famous. She wrote a book 'Lessons for Women'. This book was a kind of guide to women so that they behaved well (actually nourishing male-dominated culture) and upheld the the family traditions.

Although it insisted on the education of women, women were expected to utilize it to serve their husband, brothers and father well. Ben Zhao was also famous for her knowledge of astronomy.

Zhenyi Wang was relatively 'modern' and she never supported the belief that education should be only for serving men. She thought that women also have thirst for knowledge and should not be stopped from learning. When one thinks of science and scientists, one imagines only of men. When one thinks of a woman the picture that comes in the mind is that of a one who is busy working in the house, cooking, knitting, sewing or doing embroidery. She should at the most do some paintings or compose poems! Women surrounding her hardly bothered about anything else. Seeing all this she used to tell women, from the bottom of her heart, that they should get opportunity to get education, think, write and publish their work equally like men. Families and society should not just allow but encourage women to get educated. One can say that Zhenyi Wang was the first Chinese female scientist representing modern China.

Zhenyi Wang's contributions to astronomy have been honored in recent times. In 1994, a crater on the planet Venus was named after her by the International Astronomical Union.

Ada Lovelace

MOTHER OF COMPUTERS...

(1815 – 1852)

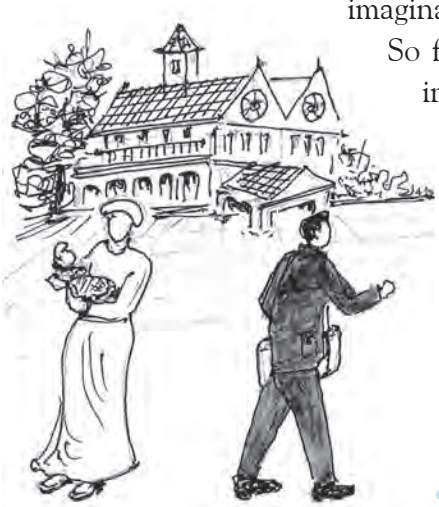
Now-a-days computers have become indispensable. Since1990, computers have been widely used. The idea of a computer, however, dates back to around 1842. Ada Lovelace, a wealthy, noble woman played an important role in shaping how computers should work. She wondered, instead of a machine that can only do division, addition, subtraction, multiplication or crunch just large numbers, can a machine be developed that can interact with humans, independently take some decisions based on the preset commands. Ada Lovelace did not just wait at the idea but wrote first algorithm or computer command. That is why Ada Lovelace is known as the mother of computers.

CHAPTER FIVE

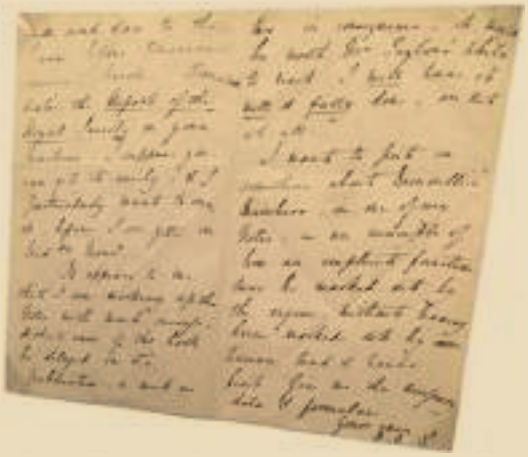
The Lovelace's country home at Horsely Towers, Surrey
Photograph 2006 by Jacqueline Banerjee. The Victorian Web

Ada Lovelace was born on December 10, 1815 in London, England in a noble and wealthy family. Her father Lord Byron was a well-known poet in England and mother Anne Isabella Milbinke, was a rich woman. Her father was very disappointed when Ada was born because he expected that he would have a son! Ada's mother already fed up with Byron's whimsy, wit, and arbitrariness left him with just one month old Ada. Ada's mother immediately gave Byron a legal notice of separation. According to the law at that time in England, the father had the right over the child. Byron not only gave up the right, but also left the country barely four months after Ada's birth. Eight years later, Lord Byron died in a Greek war. His body was brought back to England and buried in a church in Nottingham. Thus, he did not even see Ada's face after her birth. Ada's mother used to extremely hate Lord Byron due to his demeanor and temperament. She feared that even Ada would inherit her father's traits. So, she saw to it that Ada did not get interested in any type of literature! Not only that, she took precautions that till the age of 20 even Ada's father's oil paintings would not be seen by her! As a result, since her childhood, Ada began to hate her father.

For many years, since her childhood, Ada used to be constantly sick. From 1829 to 1831 she was almost nailed to bed. Her mother was ignoring her and Ada was taken care of by her grandmother. Only in society Ada's mother used to show off as if she cared a lot for her daughter. One thing is for sure that using her own wealth and place in the society, she took good care of Ada's education. She arranged private lessons for her from scholars like Mary Somerville, William Friend and William King. However, she insisted on Ada's learning only grammar, mathematics and science. Ada was literally forced to study only these subjects. After recovering from the illness, when she started walking a little, Ada's imagination began to thrive. She wished to fly in the sky.



So far Ada had made a good progress in mathematics and science. She assembled paper and bird feathers and started to see if the wings could be made. She attempted to fly like birds even using steam! She recorded these possibilities. Charles



The first computer program – Letter from Ada Lovelace to Charles Babbage 1869.
Ada Lovelace closely worked with Charles Babbage on the design of his 'analytical engine', a machine for performing mathematical calculations, widely regarded as the forerunner of the modern computer. In the above letter, Lovelace suggests an example of a calculation which may be worked out by the engine without having been worked out by human head and hands first. This was the first time the principle of the computer program had been set out in writing.

Babbage, who had been for a long time busy making machines (or calculators) that analyzed numbers, used to call her 'flying fairy'. Later, Ada and Charles Babbage – the father of computers, did a lot of work together.

At the age of about 19-20, because of her well-known family Ada began to very smoothly go around in the social circle. Her progress in mathematics and science used to be a topic of discussion everywhere. She was in contact with scholarly scientists like Andrew Cross, David Brewster, Charles Wheatstone and Michael Faraday. Ada had a reputation of being a brilliant-headed, studious and wise woman. Ada and Mary Somerville, appointed by Ada's mother for the subject of mathematics, had developed a friendly and close contact. Ada and Mary spent a lot of time together. At that time Somerville was known as a great mathematician. In 1833 she introduced Ada to Charles Babbage. Babbage once called Ada to see the number-crunching machine (he used to call it 'difference machine') built by him. The machine weighing two tons, had about 4,000 parts. Ada was highly impressed when she saw his machine doing mathematical calculations. Immediately she sent a request letter to Babbage asking him to make her a disciple. But Babbage was very busy with finding out how with some improvements his machine could be used by factories. So,he ignored Ada's request. However, Ada and Charles Babbage met frequently and their discussions used to be focused on mathematics. They remained friends forever!

Ada married William, 8th Baron King, on July 8, 1835. They had three children, Byron, Anne Isabella and Ralph. Ada's husband was proclaimed in 1838 as 'Earl of Lovelace.' So Ada also became a countess of Lovelace. They owned 3-4 luxurious estates.

Around this time, Ada started to use her mathematics skills somewhere else! She started gambling, thinking that using mathematics she will make lot of money! But that was not to be. Ada raised a mountain of debts and finally she had to tell her husband about her wrong deeds.

> **She wrote some code just on the paper itself, and she's really somebody we point to it in our heritage as our founder for computer science.**
>
> – *Megan Smith on Ada Lovelace*

Thereafter, however, Ada seems to have put her knowledge to good use.In 1840, Charles Babbage along with his number-crunching machine also initiated the idea of an analytical machine. Babbage gave a lecture at the Turin University in Italy. His speech was translated in French by a young gentleman, Luigi Menabrea and was soon published. Babbage's friend Charles Whitestone knew Ada's mathematical skills. He also knew that she was fluent in French. So he asked Ada to translate the speech from French into English. Ada quickly agreed. She did the translation, but it had some of her own notes. Eventually these notes became bigger than the main speech! The thoughts in the notes were a step towards the computer. In Babbage's original machine (called a 'difference' machine) large and complex mathematical equations (such as solving polynomials) could be done with the help of the machine. That is why Babbage is known as the father of computers. But, Ada took it one step further. She suggested, to go beyond the difference machine. She proposed to make an advanced machine that uses Bernoulli numbers to solve mathematical equations. She also suggested the necessary commands to be given to the machine. These are used in the computers we use today as algorithm or programming. If the 'analytical' devices such as today were available in her time then the expected answers could be extracted using the Ada's program by the machines even in her times. She also came up with the idea of printing on thick paper like on clothes and making holes in them to give orders or commands through them to the machines. This printing of 'punching cards' was used for the first generation of computers.

The contemporary scientists welcomed the advancement in the difference machine. Michael Faraday also appreciated Ada's idea. Today, the commands written by Ada are considered to be the first computer program in the world.

Probably because she inherited a dreamy mindset from her father she thought of a machine, not to be used just by the scientists and engineers but that also which would

> **The intellectual, the moral, the religious seem to me all naturally bound up and interlinked together in one great and harmonious whole.**
>
> – *Ada Lovelace*

be useful to the society. She dreamt of a machine that could interact with the humans! She further mentioned the possibility of composing music through the command system.She had as if imagined today's robot! However, she was of the opinion that artificial intelligence was not possible which became the matter of debate.

The idea of an algorithm for a computer is one of the greatest contributions Ada Lovelace had made. Shortly after making such important contributions, just at the age of 36 that is, on November 27, 1852, Ada died due to cervical cancer. Interestingly, she had told Babbage that she wanted to be cremated by the side of her father! According to her wish she was buried down near her father, at St. Mary Magdalene's Church in Hucknall, Nottingham, England next to his tomb. She had apparently hated her father throughout her life but there might be a latent love somewhere in her heart for her father. She never saw him, as her mother always spoke to Ada in the negative about him. Ada's last wish could have been a counter reaction!

It appears that Ada Lovelace came into the limelight after 1977. Increasing use and popularity of the computers probably is the reason behind it. Dramas based on her life were staged and even some movies were released. In some countries even some comic films were released. At some place her meeting with her father after death has been dramatized. In many instances she has been shown to be very brave and bold.

Ada was honoured in many countries. The Defense department of United States of America named an algorithm as 'Ada' and in 1980 it was officially adapted. How could her own country remain silent? British Computer Society instituted 'Lovelace Medal' since 1988 and from 2008 it also started a competition for females in her name. Every year it also organizes a 'Lovelace' conference for college girls.

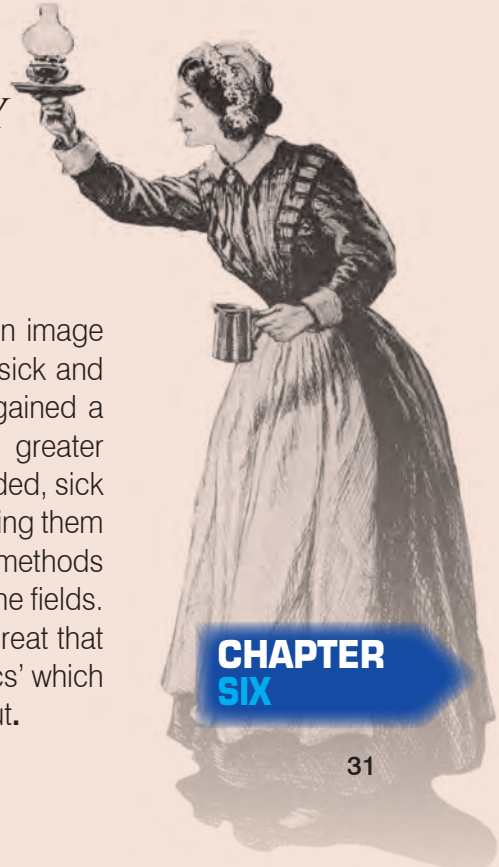
The town Tottenhamin England has 'Ada Lovelace' college and near the village Pollok a computer center was named after her. In Spain Zaragoza University computer science department is named as 'Ada Byron'.

A magazine named 'Ada' has been published since 2012. On March 8, 2017 Google paid homage to Ada Lovelace on the occasion of International Women's Day. Ada Lovelace will be immortal so long as computers are there.

Florence Nightingale

FIRST FEMALE SCIENTIST OF THE ROYAL STATISTICAL SOCIETY

(1820 – 1910)



When one talks of Nightingale there comes to mind an image of an angel with a lamp in her hand, attending to the sick and wounded soldiers. By the mid 19th century, she had gained a reputation as a compassionate nurse. However, her greater contibution was the analysis of the information of wounded, sick and recovering soldiers, categorizing them and presenting them in polar area diagrams. Statistical data presentation methods popularized by her are still used for data analysis in all the fields. Her great personality and service as a nurse were so great that her path breaking contribution to the subject of 'Statistics' which although was very important was not much talked about.

CHAPTER SIX

Florence Nightingale's example of nursing is one of the best examples of executing a good job without compromising. She also made significant contributions to the field of 'Statistics' while caring for the patients. Florence, received her name from the village of Florence in Italy where she was born on May 12, 1820, in a noble British family. Her elder sister, Parthenop, was also named after her birthplace, Parthenop, in Greece. The Nightingale family's last name was actually 'Shore'. But her father William and mother Francis got a huge property from William's maternal grand-uncle, Peter Nightingale, on the condition of changing their last name, which they accepted. William Nightingale had large estates in Derbyshire and Hampshire in England.

When Florence was five years old, the Nightingale family returned to England, living sometimes here and sometimes there in the luxury in their homes in Derbyshire and Hampshire. At a very young age Florence was taught German, French, and Italian by her father.

Florence was beautiful and well-built. Her demeanor was very charming, polite as well as lively. Coming from a highly affluent family, her mother was aware of the high status of her family in the society and also focused on elevating its position. The nature of Florence was just the opposite! She did not like to be the center of anyone's discussion or to stand in front of anyone or participate in the programs of highbrow and rich people. She rather preferred to go to the homes of the poor people around her house and serve the sick. Her parents and elder sister did not like her behavior. They wanted her to be cheerful, like the other girls of the rich people at that time and choose a rich boy to marry and be content with her family.

Things changed in Florence's life in 1838 when her father moved to Europe with his family. There he met Mary Clarke, a friend, born in England, but who lived in Paris. Although Mary herself was wealthy, she did not have much respect or was interested in the conversations of the women in the 'upper' society of the time. She preferred to talk to men who had more intellectual discussions. Mary noticed the uniqueness of Florence and was spending a lot of time with her. The gap of almost 27 years between their ages did not interfere with their friendship. They remained in contact for about 40 years. Mary thought that men and women were equal and that women were not inferior to men. Florence agreed with Mary's thoughts. Florence too had very few female friends. One of her friends was Sister Mary Claire Moore. During the war in Crimea, she worked with Florence. However, Florence's experience was that she got more help from men than women.

Florence was more inclined to serve people than to marry. The family did not like it. Florence was tired of trying to convince them. However, she was getting along very well with a friend Richard Milnes and her mother thought that he was the perfect 'bridegroom' for Florence. Florence liked Milnes but was thinking that marriage would be a hindrance in her path. She wished to spend the rest of her life in helping patients, so she turned her back to Milnes.

After some heated arguments with her mother and elder sister, Florence began spending her time studying science and nursing. Finally, in 1844, Florence went to the Lutheran Hospital in Kaiserswerth-am-Rheine, Germany to study medicine. Six years later, in 1850, Florence returned to London. But instead of going home, Florence straight away went to work at Middlesex Hospital. Florence Nightingale's superiors were so pleased with her work that within a year they promoted her to the manager's post. Her task became more and more challenging, as within a few days of her joining cholera spread out in London. All eyes were fixed on ways to reduce the number of hospital deaths. Florence was quick to point out that lack of sanitation in the hospital was a major factor in the spread of the disease and contributed to increase of death toll. She emphasized on the cleanliness in the hospital and found that the disease was soon under control. But the stress of work began to show on her health. Yet her important and difficult task was still ahead!

On October 16, 1853, war broke out between the British Empire, French Empire, Ottoman Empire, Sardinia, and the Russian Empire in the Crimean region, north of the Black Sea. Thousands of British soldiers were sent to Crimea. But due to lack of adequate equipment and foodgrains, the army was soon reduced to dust and it was time to admit many soldiers to the army hospital. At that time the situation in the hospitals was very alarming. Due to shortage of staff and lack of sanitation everywhere numerous soldiers were dying.

In 1854, Florence Nightingale received a letter from the Secretary of War, Herbert Sidney asking her to assemble a group of nurses and visit the Army at Crimea to take care of soldiers. At that time, more than 20,000 patients were admitted in the Army Hospital. There was a great shortage of women working as nurses. Florence quickly assembled a group of 34 nurses and left for Crimea.

The condition of the army hospital in Crimea was indescribably filthy. The patients were lying anywhere, there was no clean water to drink and their clothes were dirty! There was dearth of air and light. Injured patients were not even bandaged and those who were bandaged, their bandages were never replaced. There was free movement of rats, beetles and insects. In such cases, it would

not have been a surprise if the patient were dead! Upon arriving, Florence Nightingale realized that more casualties were caused by filth than by war. So the first thing she did was to clean the hospital walls, ceilings, floors, and improve the patient's diet. She began to take the patients in open air and sunlight. Florence spoke to patients affectionately and tried to boost their morale. Her efforts were successful. However, the British Army and the Government had to be convinced about it! So she began to study the situation in a systematic and scientific way. It came to her mind to create a visual chart of how many patients came in a month, how many were cured and how many died. From her childhood she was very good at mathematics. She decided to use the concept of 'Pie Chart' (originally proposed by William Playflair in 1801), to review the condition of patients. Using polar area diagrams or pie charts for statistical analysis of patients was a very innovative method. She divided the concentric circles using red, blue, and black, colors creating 'Polar Area Diagrams' that could effectively tell at a glance, how was the condition of the hospitalized patients. She used to call these diagrams as 'Coxcomb'. By improving the cleanliness of the hospital, she was able to reduce the number of deaths by two-thirds. With the help of polar diagrams Nightingale was able to convince the members of the parliament the importance of hospital hygiene. Based on her experiences in Crimea, she made 830 pages report from her notes. She tried to explain the importance of patients' diet, change of their clothes on a daily basis, cleanliness of the beds, sweeping the rooms, necessity of free and clean air, entertainment or reading. The book based on her notes was a great guide to military hospitals, and the Royal Commission for Army Health was established in 1857 to improve the conditions in military hospitals.

> **"I am of certain convinced that the greatest heroes are those who do their duty in the daily grind of domestic affairs whilst the world whirls as a maddening dreidel."**
>
> – *Florence Nightingale*

In the summer of 1856, Florence returned home from Crimea. There she was greeted like an unprecedented warrior. Queen Elizabeth honored her with a carved brooch, and the government with a large sum of cash. Nightingale used the money to set up St. Thomas Hospital and Nightingale Training School for Nurses. Her work was honored with poems, plays and songs. Due to Florence Nightingale, nursing was no longer considered a lowly profession but a respectable one. In 1859

Florence was elected as a member (first female) of the Royal Statistical Society and in 1874 as honorary member of the American Statistical Association. This shows the importance of her contributions to Statistics and Science.

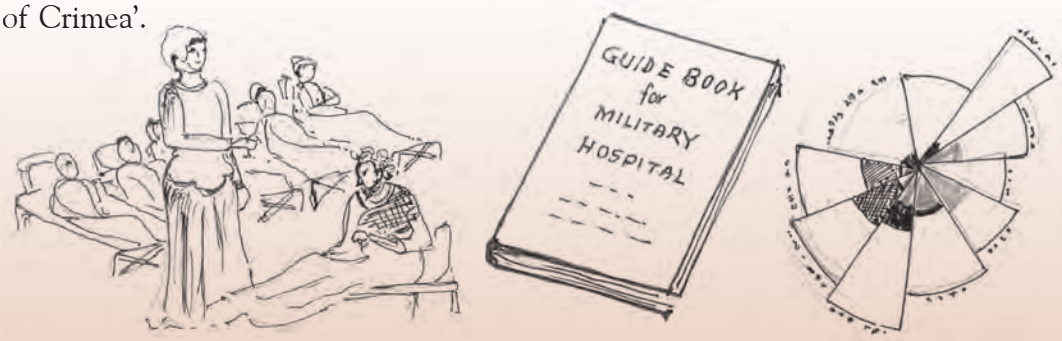
Florence's health did not improve much since she returned from the battlefield in Crimea at the age of 38. Most of the time she stayed in bed but worked a lot while sitting in bed. She read and wrote several books and reports.

Although Florence had never been to India she had read and heard about the Indian villages. She tried her best to set up a sanitation scheme by setting up a commission for reforms in British-occupied India.

Florence Nightingale died of old age at her home in London on 13 August 1910. Her career spanned suitable to her longevity. She specialized in Nursing and Statistics. She published 200 books and some pamphlets. She had given her views especially on 'Feminism' and commented on religiosity.

Florence Nightingale didn't really like fame, but because of her work, fame was running after her! Not only short and long articles but also books were written on her. She has been featured in movies and television shows in recent times. There are also hospitals named after her in Turkey and some places in England. Her statues were set up in many places, and she is immortalized in a stained glass window in St. Peter's church in Derby, England. Her picture was printed on 10 pounds banknotes between 1975 and 1994. One plane of K.L.M. airline was named after Nightingale. Although Florence Nightingale is a woman who is an inspiration for the nurses and is remembered in many countries yet her contributions to science are not very familiar. Maybe there was so much expanse of her social work that her contributions to science remained obscure.

People wanted to bury her with national honors and Westminister Abbey was an option but according to her last wish, her family simply buried her on her family's land at St Margaret of Antioch Churchyard in Hampshire, England. Florence used to walk around the hospital rooms day and night carrying a lamp to serve the patients. Therefore, she was known as 'Lady with the Lamp' or 'Angel of Crimea'.



Mary Corinna Putnam Jacobi

Women are not weak ...

(1842 – 1906)

For centuries women have been deprived of education and other rights. Even developed countries like America are no exception. In the 19th century, due to some unsubstantiated statements made by a medical professor of a prestigious university like Harvard regarding women as weak and that they should not pursue higher education, some universities began denying admission to women. By becoming a doctor herself, Mary Jacobi paved the way for women's education by proving that women are strong and their education does not harm their health. She systematically collected ample data to prove her point which lead to opening the doors for women in higher education.

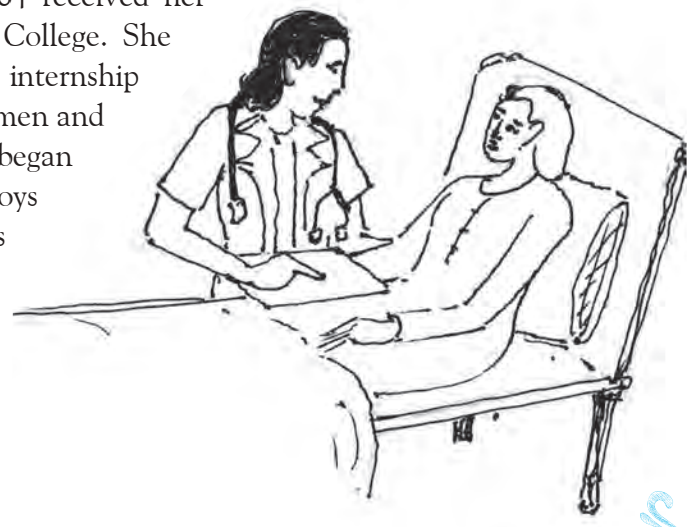
CHAPTER SEVEN

FIRST WOMAN'S MEDICAL COLLEGE BUILDING.

AS IT APPEARED AT THE FIRST COMMENCEMENT IN 1850, LOCATED AT 229 (OLD NUMBER) ARCH STREET, BELOW SEVENTH.

Mary Jacobi was the second American woman to become a doctor. She was the eldest child of Victorine Havan Putnam and George Palmer Putnam amongst their 11 children. She was born on 31 August 1842 in London. George Putnam was setting up a London branch of 'Wylie and Putnam' publishing company. Therefore, he was in London with his family there. But when Mary was seven years old, her parents returned to the United States in 1848. Mary's childhood and youth was spent in New York city. Due to their book publishing family business Mary had developed a good interest in literature and languages. Much of her education was at home due to her mother. But for two years before graduating in 1859, she attended a public school for girls. *She* then learned Greek. Some of her articles were published in a magazine called Atlantic. One of her stories, 'Lost and Found', was published in 1860 and was highly praised. There is no surprise that her father hoped that she would get interested in running the family business of publishing the literature. But Mary decided to become a doctor. Her father strongly opposed this idea, but Mary did not change her mind. Since her childhood Mary would do what she wanted! It was not possible for mother, father or anyone to change her mind! At the age of nine, she saw a dead rat, and she wanted to cut it and see what its heart was like. But at that time, she did not have the courage to do so. Nonetheless, she had a strong curiosity to see what the body looked like inside. She had dreamed of becoming a doctor since her childhood. Unwillingly her father decided to support her to get a medical education. Thereafter she did not have much difficulty in getting further education.

In 1863, Mary graduated from the New York College of Pharmacy, and in 1864 received her M.D. from the Female Medical College. She then spent a few years doing an internship at a New England hospital for women and children. During this time, she began to insist on educating girls and boys together. The reason for it was that girls' colleges were not as big as the medical colleges for boys. As a result, girls did not get as much practice and experience as boys. It was then that she realized that if she wanted to pursue an independent medical career, she needed to get more

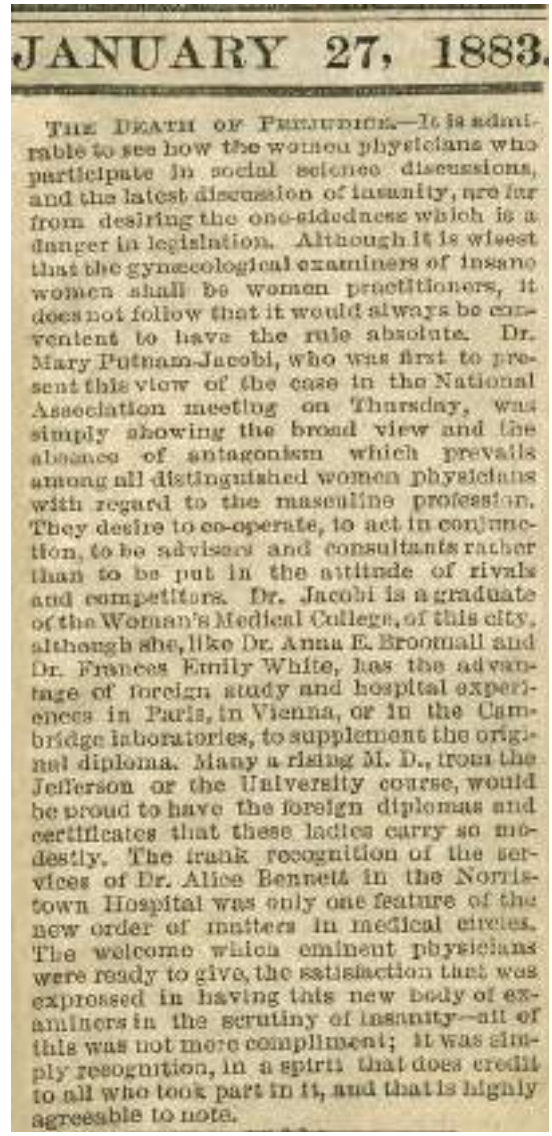


> **No matter how well-born, how intelligent, how highly educated, how virtuous, how rich, how refined, the women of to-day constitute a political class below that of every man, no matter how base-born, how stupid, how ignorant, how vicious, how poverty-stricken, how brutal. The pauper in the almshouse may vote; the lady who devotes her philanthropic thought to making that almshouse habitable, may not. The tramp who begs cold victuals in the kitchen may vote; the heiress who feeds him and endows universities may not.**
>
> – *Mary Corinna Putnam Jacobi*

education. Therefore, she decided to go to France. Again, after somehow convincing her parents, she moved to France in 1866. There in Paris, she spent a few days at the École Practi attending lectures, practices and clinics. But then Mary decided to enroll in the École de Medicine at the University of Paris. But even there, Women were not getting access to the University education. But it was not Mary's nature to give up. With a lot of follow up (she even put pressure on the university from the Minister of Education) eventually Mary was to become the first woman to get admission in a medical college. She was admitted in January 1868. Until then, for 1-2 years, she wrote articles, stories and correspondence in various American newspapers and magazines. But once she started studying in 'École de Medicine', she completely focused on the study. Mary was the only girl and that too an American in college. Mary was the subject of curiosity! When she went to class, she had to go in through the door used by the professor and sit next to him. In the beginning this privilege made her awkward but soon she got mixed up with the atmosphere. In 1871 she not only received a medical degree but her dissertation also won the award for best dissertation.

Mary returned to the United States in the same year, and she immediately began an independent medical practice in New York City. At the same time, she began teaching at the Women's Medical College of New York, with a hospital for women and children. Around the same time, in 1873, Edward Clarke, M.D., a professor at Harvard Medical College published a sensational book titled 'A Fair Chance to Girls'. In his book he emphasized that it puts a lot of stress on girls who are

pursuing higher education, especially medical education. He stated that as a result girls become physically weak and lose their fertility. He advised the parents not to teach too much for the sake of girls! He was bold enough to say that he was writing it with his longstanding experience! Already society at that time was not very enthusiastic about the education of women and there was such a statement against educating women. That too it was the opinion of an expert! Even before the universities closed their doors to women, parents began to oppose girls' higher education.



JANUARY 27, 1883.

THE DEATH OF PREJUDICE.—It is admirable to see how the women physicians who participate in social science discussions, and the latest discussion of insanity, are far from desiring the one-sidedness which is a danger in legislation. Although it is wisest that the gynæcological examiners of insane women shall be women practitioners, it does not follow that it would always be convenient to have the rule absolute. Dr. Mary Putnam-Jacobi, who was first to present this view of the case in the National Association meeting on Thursday, was simply showing the broad view and the absence of antagonism which prevails among all distinguished women physicians with regard to the masculine profession. They desire to co-operate, to act in conjunction, to be advisers and consultants rather than to be put in the attitude of rivals and competitors. Dr. Jacobi is a graduate of the Woman's Medical College, of this city, although she, like Dr. Anna E. Broomall and Dr. Frances Emily White, has the advantage of foreign study and hospital experiences in Paris, in Vienna, or in the Cambridge laboratories, to supplement the original diploma. Many a rising M. D., from the Jefferson or the University course, would be proud to have the foreign diplomas and certificates that these ladies carry so modestly. The frank recognition of the services of Dr. Alice Bennett in the Norristown Hospital was only one feature of the new order of matters in medical circles. The welcome which eminent physicians were ready to give, the satisfaction that was expressed in having this new body of examiners in the scrutiny of insanity—all of this was not mere compliment; it was simply recognition, in a spirit that does credit to all who took part in it, and that is highly agreeable to note.

An 1883 newspaper clipping, praising women physicians

Mary Putnam, however, decided to study this type of scripture. She took medical tests of several young girls before, during and after their menstrual period. She recorded if they had some discomfort, pain, fatigue, body temperature, rectal temperature and made urine analysis as well as checked their pulse, heart rate, and their diet. Based on these results she made a few graphs and charts. She then wrote a 232-page article. In which she showed that women's mental and physical capacity had nothing to with menstruation. Even during menstruation, women can function properly, as usual and their fertility is not affected by brain stress! She speculated that women do not even need rest during menstruation. Mary's article, with its scholarly statements, removed a major obstacle to girls' education. Prof. Dr. Edward Clark's futility was exposed to all. Interestingly just three years after Professor Clarke's book, Mary was awarded the Boilston Prize by Harvard University itself for this piece of work! The doors of the university were opened to the girls for higher education. Even parents had no hesitation for the girls' education. In fact, it was a good example of her

> **My whole existence is governed by abstract ideas… the ideal must be preserved regardless of fact.**
>
> – *Mary Corinna Putnam Jacobi*

own to show that higher education has nothing to do with fertility. In 1873, she married Dr. Abraham Jacobi. Dr. Jacobi himself was known as the father of pediatrics.They had three children, two daughters and a son.

Mary Putnam spent her life trying to get medical education for women. In 1872, she founded the Institute for Women's Medical Education. From 1874 to 1903, she was the president of this organization. She was also a member of several medical associations. She was the first honorary female member of the New York Medical Association. She was a member of the Medical Association as well as the New York Pathology Association. She wrote more than 100 research papers. Mary became known as a writer, researcher, and independent thinker working on women's issues. Rational and scientific perspectives were important qualities of Mary Putnam Jacobi, even in her final pain. When she was diagnosed with a brain tumor she objectively wrote down the symptoms of the meningeal tumor and its effects, as if described by an alien patient. Finally she also wrote that 'that's how author's own death occurred.' Mary Jacobi died on June 10, 1906 in New York. She was buried in Greenwood Cemetery in Brooklyn, New York. Many eminent doctors were present for her funeral.

> On June 10th, 1906, American physician Mary Putnam Jacobi died of a brain tumor. Her death, similar to her life, was not without careful contemplation. Dr. Jacobi detailed her own demise in an account, titled "Descriptions of the Early Symptoms of the Meningeal Tumor Compressing the Cerebellum".

Excerpts from the medical records of Mary Putnam Jacobi — meticulous record of the patient by the patient herself

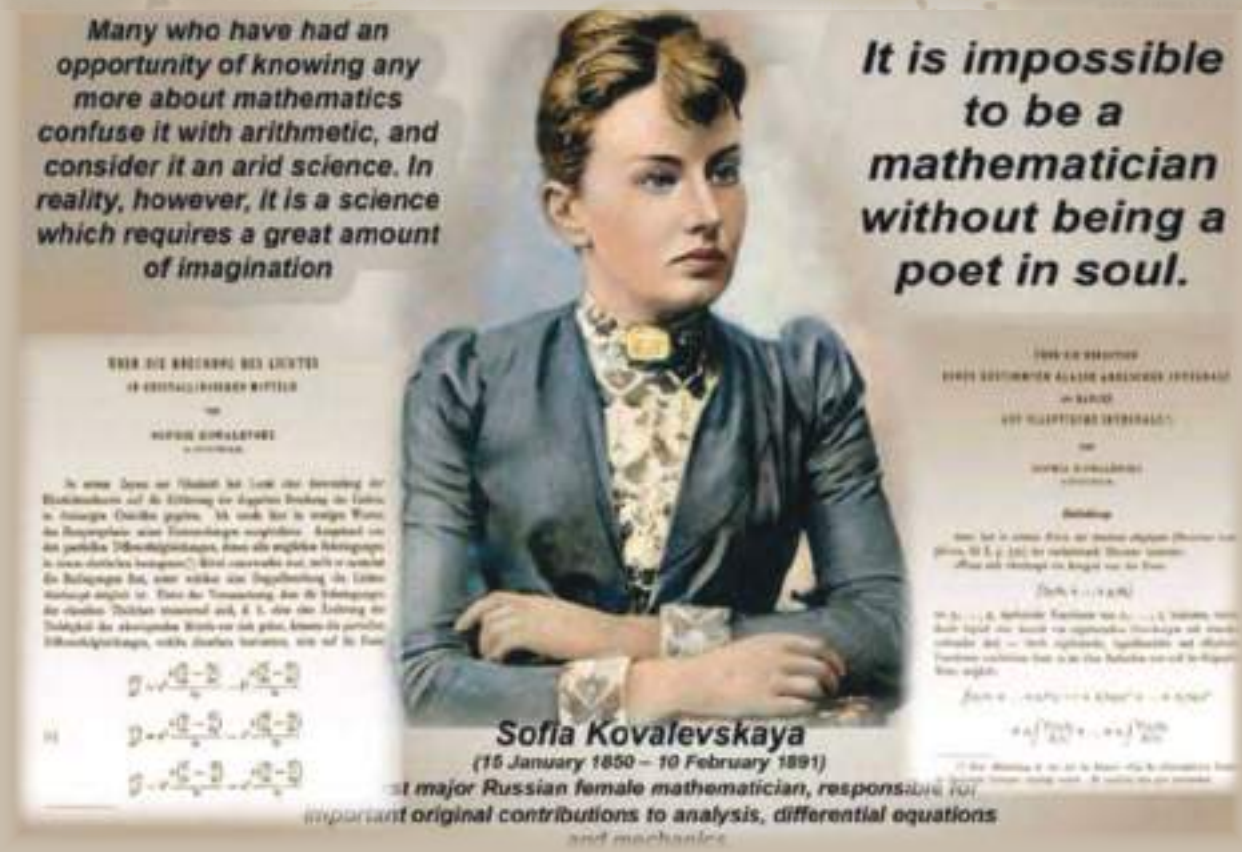
- *It seemed to me often as if I lived in a glass house on the summit of a lofty mountain where I could see in every direction an almost illimitable distance looking through an atmosphere of blue and gold… I emphasize this habitual condition because it was on account of it that the first symptoms of the present illness became so conspicuous from contrast and attracted my attention, as otherwise they might not have done.*
- *From time to time I have fallen suddenly — not when out of doors, most frequently upon arising after sitting for a long time, perhaps especially in the evening. I would fall to the floor, and experience considerable difficulty in getting upon a chair. The fall was unaccompanied by either vertigo, giddiness or pain. Indeed no different sensation in any part of the body: the legs simply gave way as if I had been on skates. After a moment or two, I could climb to my feet again and felt none the worse for the adventure.*
- *There was a facility of fatigue after mental exertion, quite comparable to that after walking. This became marked at the same time with the latter, that is after June, 1903, although the sense of loss of initiative had begun, as I have said, six years before. In the last week I have had for the first time a dragging heaviness in my left arm, and some stiffness when I move it backward.*

Sofya Kovalevsky

Anything for Mathematics...

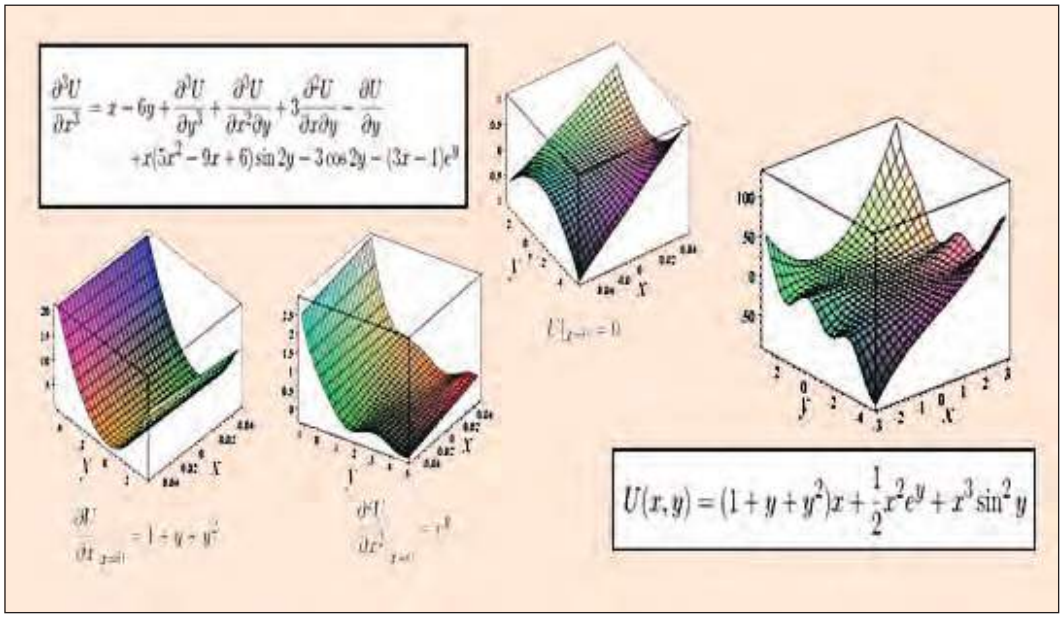
(1850 – 1891)

Sofya Kovalevsky was a 19th century Russian mathematician. Women in Russia were not getting education in their own country neither were they allowed to travel abroad without their father or husband. Sofya pretended to have been married to Vladimir Kovalevsky, a young geologist and eloped to Germany. After stepping in Germany she came to know that there too women were not allowed to be admitted for University education. She struggled a lot to fight the system and found her ways to study mathematics by pursuing the professors and impressing them later. Thereby she not only got a doctorate in mathematics but became the first female university professor in Europe.


Many who have had an opportunity of knowing any more about mathematics confuse it with arithmetic, and consider it an arid science. In reality, however, it is a science which requires a great amount of imagination
It is impossible to be a mathematician without being a poet in soul.
Sofia Kovalevskaya
(15 January 1850 – 10 February 1891)
t major Russian female mathematician, responsible for
important original contributions to analysis, differential equations

Sofya Kovalevsky (born Korvin-Krukovskaya) was a brave and intelligent Russian woman who struggled a lot in the 19th century but considered a dry subject like mathematics as wonderful as poetry. One can rarely find such examples in history. Sofya was born on January 15, 1850, in Moscow, Russia. Her father's name was Vasily Vasilyevich Korvin Krukovskaya. Her father had retired from the post of Lt. General from the Russian army. Sofya's mother, Yelizaveta Schubert was a German. When Sofya was very young her parents went to live at their family estate near the forest on the Russia-Lithuania border in rural area. Sophia was raised there. After moving in, they started decorating their big house. Her father ordered a nicely embossed colored paper to paste on the walls of the house. But as it turned out, Sofya's father noticed that they were short of the paper for little Sophia's room! So, he had a brilliant idea! He tore up his old college mathematics books and stuck the pages like collage on the walls in her room. The numbers on the walls, the different symbols, the figures, the equations didn't make any sense to 4-5 years young Sofya but she would stare at the walls for hours without getting bored.

In her childhood, Sofya's parents appointed a Polish teacher to come home and teach her. There lived a physics professor next door. One day he gave a physics book written by him to her father to read. Sofya read it completely. A few days later, the professor again came to visit Sofya's father. Sofya started talking to him about his book. Initially he didn't pay attention but was surprised to



Cauchy-Kovalevskaya Theorem

> **The meaning of these concepts I naturally could not yet grasp, but they acted on my imagination, instilling in me a reverence for mathematics as an exalted and mysterious science which opens up to its initiates a new world of wonders, inaccessible to ordinary mortals.**
>
> *– Sofya Kovalevsky*

see her understanding of the subject. He compared her directly to a great scientist like Louis Pasteur. This made her father think about the need to teach her more. Seeing her interest in mathematics he arranged for a famous teacher from St. Petersburg to teach her mathematics. The teacher was an advocate of women's education. Sophia got to learn calculus from him. There was a library in Sophia's house. In addition to the books, many magazines were procured regularly. Sophia would read them all. Although she studied on her own considerably, yet she realized that she had to learn a lot more and needed regular university education.

In her view, mathematics was as romantic and beautiful as poetry. She felt that just numbers and addition-subtraction or multiplication-division from arithmetic does not mean mathematics, but there were numerous beautiful possibilities as well. It is only after lot of imagination that the beauty in mathematics slowly reveals itself! However, at that time, the spread of women's education had not started in Russia. Sofya did not see the possibility of further education. Moreover, her father was not inclined towards women's education. Sofya had learnt enough at home and in her father's opinion that was sufficient. Sofya thought of going to Germany to study mathematics. But her father would not allow it. The Russian women at that time needed the written permission of father or husband to go abroad. So Sofya came up with a trick. She and Vladimir Kovalevsky pretended to have married and the two went to Germany. There he left her in Heidelberg as per their mutual understanding and went to another place. This way both of them became independent!

Sofya first tried to obtain admission in the University of Heidelberg. But even in Germany, women were not allowed to get university education at that time. Not knowing this before arriving in Germany, Sofya was shocked at first but not discouraged. She made many requests to university professors just to attend their lectures and finally succeeded! She was allowed to sit in their lectures. Another girl, Julia Lermontova from Russia also came at that time. She could come

because of her father's encouragement. She was interested in studying chemistry. Julia and Sofya became good friends. As recounted by Julia, in Heidelberg, Sofya became so famous due to her extraordinary abilities that even strangers would stop and look at her when she was walking down the street. To renowned professors like Gustav Kirchhoff, Robert Bunsen, Hermann von Helmholtz, she appeared to be a talented girl. Thus, Sofya made a very impressive start.

After spending two years in Heidelberg, Sofya moved to Berlin. She decided to pursue a career only in mathematics under the supervision of Professor Karl Weierstrass. Professor Karl Weierstrass taught at Friedrich Wilhelm University in Berlin. Even there, women's education was prohibited. Moreover, Professor Weierstrass had no interest in the education of women. In fact he was somewhat averse to it. However, after interacting with Sofya he recognised her ability in mathematics and her passion for learning. He then agreed to teach her privately. Prof. Weierstrass himself was a self-made mathematician without any formal education at the university. He was awarded honorary doctorate from the University of Königsberg. Professor Weierstrass who was very famous at that time is considered to be the father of modern analytical methods in mathematics.

Sofya under with the guidance of Professor Weierstrass attended his lectures at the University of Berlin. The strict rules for women's education would not allow Sofya to get enrolled in the University of Berlin. Therefore Weierstrass got the permission to submit her dissertation to the University of Göttingen. In the year 1874 she presented three subjects as a dissertation to the University of Göttingen: Partial Differential Equations (parts of which are now known as, Kochi-Kovalevsky theory), the dynamics of Saturn's rings and elliptical integrals. The dissertation was in-depth, in both mathematics and astronomy. She became the first European woman to receive Ph.D. in Mathematics.

By now Sofya decided to turn her fake marriage into a real one. She and Vladimir Kovalevsky came together. They occasionally visited their friends in France and England. Sofya also was very 'social'. After getting her doctorate they decided to leave Germany and go back to Russia. They began to live in Moscow. Both of them tried to get a job in the university. But Sofya as a woman and Vladimir because of his anti-government political views did not get a job. They tried different independent enterprises. But there was no success and stability. At the same time they had a daughter, named Fufa. But Vladimir was also very

Google doodle in honour of Sofya Kovalevsky

capricious. As a result, both of them could not get along with each other and after sometime they separated.

Since Sofya left Germany, Prof. Weierstrass repeatedly called her back to Berlin and asked her to start work in mathematics. Eventually she decided to return back to Germany. But now she also had a responsibility of her daughter. Leaving her daughter with her elder sister, Sofya moved to Berlin. Vladimir also ran into financial trouble, and a possibility arose that he would be sued. His fickle nature probably led him finally to commit suicide in 1883!

During her stay in Berlin, in fact in the same year i.e. 1883, she got the opportunity to become a lecturer of Mathematics at Stockholm University in Sweden. This was possible with the help of Gösta Mittag-Leffler, one of the students of Prof. Weierstrass. Within six months, she was promoted to the post of professor. Two years later she became the head of the mathematics department. She also became the first woman professor at a university in Europe. She also became the first woman member on an editorial board of a journal of mathematics. Russian Academy of Sciences also offered her a 'chair'.

Sofya was thus becoming successful. She had immersed herself in work. In 1888, the Paris Academy of Science hosted an international competition. There were some unsolved problems of Mathematics in it. Sofya not only won the competition but she also won the hearts of the examiners. One of the problems was about the rigid object revolving around a fixed point. It was opined that she showed a new direction in mathematics. According to some, the importance of her work was not that she found the answer to the question or that her methods were innovative, but in the curiosity she ignited among the researchers.

Just as Sofya did an unforgettable job in mathematics, she also was quite proficient in literature. Along with her mother tongue she was also fluent in German and Swedish languages. Three of her novels became popular. At the age of 41, i.e. on February 10, 1891 she died in Sweden after she contracted pneumonia. One year before her death her old friend Julia Lermontova adopted her daughter, Fufa. Julia Lermontova had settled in Moscow. She had no children of her own and she loved Fufa like her own daughter.

There were some television series and movies on Sofya. In her honour Russia issued a postal ticket with her photograph on it. Based on her biography some books have also been written.

Kadambini Ganguly

THE FIRST WOMAN TO BECOME A DOCTOR FROM INDIA

(1861 – 1923)

Anandibai Joshee was the first woman doctor of India. But Kadambini Ganguly was the first woman doctor to study Western medicine in India. She was the first woman doctor in the whole of Asia to be educated in her homeland. In 1886, a few days after Anandibai Joshee, she became a doctor. In 1892, she went to England for further education. On her return, she set up her own private clinic after working at Lady Dufferin Hospital in Calcutta for a few days. She also did a lot of social work, taking care of the house and business. She did a lot of work, especially in the women's liberation movement.

CHAPTER NINE

Calcutta Medical College

Raja Ram Mohan Roy (1772-1833) is known as the father of Bengal Reform. He succeeded in fighting against the Sati system. In 1830 he founded the 'Brahmo Samaj.' It was an organization fighting against the oppressive social and religious practices of Hinduism. The issue of women's education was also very important from the point of view of Brahmo society.

Since 1858 to 1947 India was ruled by the British. However, the influence of English people on Indians had started from the 18th century. The young Indians were influenced by their lifestyle, thoughts, education and progressive attitude. What was impressive and different for youth of Bengal was the way in which women were treated and consulted in different matters. At that time in India most of the women of any religion or caste did not get respect in the families or society. They were not at all consulted in trivial or important issues. Everyone was of the opinion that women are born for household work and reproduction. Women also had accepted this status in the family and society for many generations. Most of the orthodox Hindus were of the opinion that if women get education then they would become licentious, families will fight among themselves and get spoiled. The young people were of different opinion. They thought that if women get education they would become better mothers and companions. Brahmo Samaj did not support the conservative Hindu traditional thoughts and was in favor of progress and equal rights for women.

Many famous men and women from Bengal at that time became members of Brahmo Samaj. Braj Kishor Basu was one of them. His hometown was Chandsi in Barisal district, now in Bangladesh. He came to Bhagalpur in Bihar for job and later settled there. He was the headmaster of the secondary school there. He also set up an organization called 'Bhagalpur Mahila Samiti' along with Abhay Charan Malik. On July 18, 1862 Braj Kishor Basu was blessed with a daughter. She was named Kadambini. In those days, having a daughter was a kind of crisis for the families, because the dowry and expenses incurred in the marriage were to be borne by the parents of a daughter. Even today, in many parts of India, the idea of ignoring or rejecting girls stems out of it. But this was not the case with the Basu family. They took pleasure in educating the girls and birth of a girl child in the family was considered to be a great opportunity.

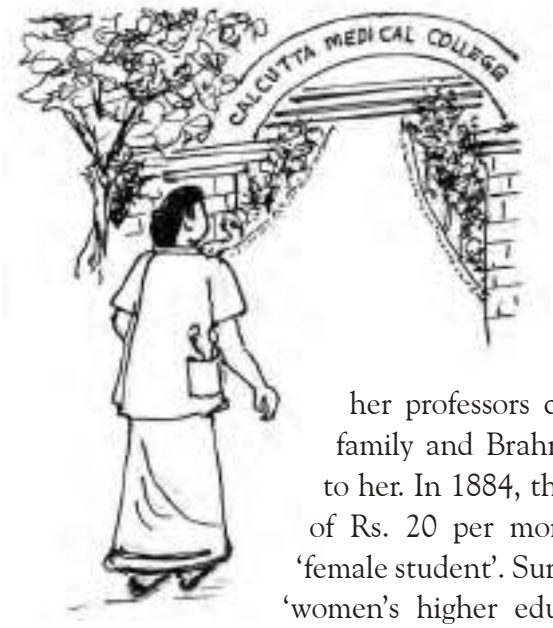
> **...Kadambini is a symbol that India's freedom would uplift India's womanhood.**
>
> *– Annie Besant*

Kadambini fulfilled her parent's wish perfectly. She started her education at Banga Mahila Vidyalaya in Bhagalpur. Her father wished that she should go to Calcutta and get higher education. Kadmbini displayed interest and progress in her school education. In 1875 she started her further education in Bang Vidyalaya in Calcutta. It was the best school for the education of girls. Besides basic mathematics, geography, history, physical training, Bengali and English they also taught cooking, embroidery and dance. The school also laid emphasis on discipline. Therefore, girls were mostly well accomplished. In one of the programs at Bethune school, Governor of Calcutta highly praised the accomplishments of Bang Vidyalaya. The working committee of Bethune school took initiative to merge Bethune school and Bang Vidyalaya. Taking special permission from Bethune school, Chandramukhi Bose and Kadambini appeared in 1878 for the entrance examination of the University of Calcutta. Both of them passed. They were the first female students to pass the entrance examination of the Calcutta University. For getting higher education at the University it was mandatory to clear the entrance exam in which both boys and girls would appear and no special concession for girls would be given. The girls displayed their mettle and showed that when given an opportunity they ar at par with the boys. Kadambini has several records to her credit like 'First Lady'! There was no college at that time which could give university education to girls. However, due to support of some who wished that women should get higher education, Bethune college could start F.A. (First Arts) followed by the degree course in 1883. Kadambini Ganguly and Chandramukhi Bose became the first women who got an Indian degree. Thereafter, Chandramukhi Bose pursued M.A. Arts course at the University and Kadambini went for medical course.

In 1883, at the age of 21, Kadambini fell in love with her 39-year-old teacher. His name was Dwarkanath Ganguly. He was a widower. Dwarkanath was a leader in the Brahmo Samaj program and especially in the 'women's liberation' movement. He was interested in solving the problems of women working in coal mines in Bengal. Their marriage was no hindrance to Kadambini's further learning. Instead, he always encouraged her to continue her education and then her job, business and social work. Love, equality, trust and respect for each other were the foundation of their happy married life. Kadambini, who became a mother of 8 children, not only lived a content life but also became an ideal woman and an activist.

Kadambini entered Calcutta Medical College in the same year i.e. 1883, as her marriage. At the same time, Abala Bose (wife of Sir Jagadis Chandra Bose) also appeared for the medical college entrance examination from other place and even passed it. But for some reason she did not get admission in Calcutta Medical College. Abala went to Madras to study but she could not become a doctor.

According to the Calcutta University rules at that time anybody who had a university degree from any college could get admission in medical college. However, Kadambini had to face considerable difficulties owing to the prevalent orthodox Hindu traditions. Many college professors could not digest the fact of a woman becoming a doctor. Several members of the working committee wondered how girls and boys could study subjects like anatomy by sitting in the same class! Many thought that tough medical courses were difficult for women and they should not be admitted. However, Bramho Samaj activists and some other progressive minded people strongly emphasised the necessity of female doctors. In those days women would not leave their homes without the company of men. When sick or during pregnancy, women did not take help of male doctors. This was the reason of large number of deaths of women and children. Lack of education and dearth of medical assistance was the main cause. In case of any difficulty during childbirths midwives were called by family members to help the pregnant women. Midwives too were not trained and they depended only on their limited experience and more on luck. The government also wished that there be female doctors in order to control the untimely deaths of women and children.



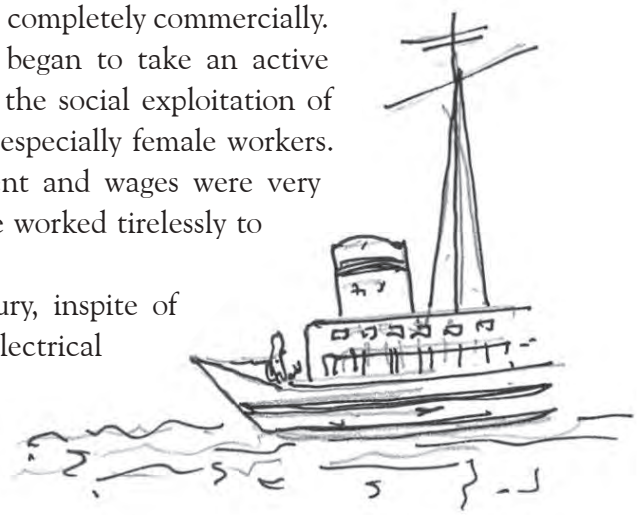
When the social pressure increased, government intervened and made it compulsory for the medical college to admit girl students. As a result Kadambini got the admission in June 1883 in medical college in Calcutta. Although her medical college education started, socially Kadambini used to be targeted by some people. Even some of her professors continuously troubled her. Fortunately her family and Brahmo Samaj community was very supportive to her. In 1884, the government paid Kadambini a fellowship of Rs. 20 per month. She started getting scholarship as a 'female student'. Surprisingly, even in many European countries, 'women's higher education' was a contentious issue, yet the

> **This young lady, Mrs. Ganguly, married! After she made up her mind to become a doctor! And has had one child since. But she was absent only thirteen days for her lying-in!! And did not miss, I believe, a single lecture!!**
>
> *– Florence Nightingale*

British government encouraged women's education in India under its rule. Unfortunately, the hurdles created by some professors resulted in her not passing in one of the practical examinations of the final paper of pharmacology. However, she managed to pass all the other examinations well and got the degree of 'Graduate of Bengal Medical College (GBMC)'. So she got a license to do independent practice as a doctor. Thus, in 1886, Kadambini Ganguly became the first woman in India to study Western medicine.

Kadambini Ganguly's fame was already spreading in the world. In 1888, Florence Nightingale wrote a letter to one of her friends asking for more information about Kadambini Ganguly. She was surprised that an Indian woman with a child was studying in a medical college and she had not missed even a single lecture!

After a few days of independent practice, in 1888, Kadambini worked for a while at Dufferin Women's Hospital for a salary of Rs. 300 per month. She then went to England for higher education. In 1892 she obtained the degree of LCPRS from Edinburgh, LRCS from Glasgow and GFPS from Dublin. After working for a few days at Dufferin Hospital, she resumed her independent practice. However, she did not run her clinic completely commercially. She served for the social cause. She also began to take an active part with her husband in the fight against the social exploitation of workers in coal mines and tea plantations, especially female workers. The problems related to getting recruitment and wages were very serious and oppressive. The Ganguly couple worked tirelessly to raise their voices against them.



Nowadays, compared to the 19th century, inspite of having access to many mechanical and electrical appliances in their homes women find it difficult to balance work and home responsibilities and manage 1-2 children.

Hail Dwarakanath's fight to procure the needed permission, both Kadambini and a girl named Sarala were allowed to appear for the CU entrance exam in 1877.

But Kadambini had 8 children and she was managing her doctor's profession and social work. Moreover, her husband was also happy! It is surprising how Kadambini could successfully manage all the roles. Probably this was possible only due to her courage, strength and strong will power.

In 1885, the Indian National Congress (INC) was formed. Dwarkanath Ganguly began to represent the issue of women at its annual meeting. Kadambini attended its 5th Annual Conference with great enthusiasm. She was the first woman to speak in it. In 1906 she organized a convention of women. She also chaired the meeting in 1908 organized to support the Indian workers' satyagraha in Africa. She also raised

Residence of Kadambini Ganguly
(Credit: commons.wikimedia.org)

> **...Kadambini, was the most accomplished and liberated Brahmo woman of her time. Mrs. Ganguly's ability to rise above circumstances and to realise her potential as a human being, dedicated ideologically to the liberation of Bengal's woman...**
>
> *– David Kopf, American Historian*

some funds to help the activists. During Mahatma Gandhi's visit to Calcutta in 1914, she presided over a meeting of the Brahmo Samaj in his honor.

Although Kadambini was efficiently working as a mother, housewife, doctor and a social worker, some orthodox Hindus with conservative views launched a campaign to discredit her. The Bengali newspaper 'Bangabasi' started publishing defamatory news against her. They went so far as to call her a 'whore'. It was therefore time for her to take legal action against the newspaper. She sued them in the court of law and won the case. The editor of the newspaper Mahesh Chandra Paul was fined Rs. 100 and sentenced to 6 months imprisonment.

In 1922, the government asked Kamini Roy, a Bengali poetess and social worker, and Kadambini Ganguly to investigate the situation of women workers in Orissa and Bihar, especially in the coal mines. Kadambini completed her task by making visits to Orissa and Bihar.

Kadambini Ganguly died on 3rd October 1923 at the age of 63. At a time when women were totally confined to the homes, only doing household work, Kadambini displayed extraordinary talent on different fronts, overcoming the surrounding conditions. She served the society as a doctor, feminist and social worker. This was solely achieved on the basis of her strong will coupled with confidence, talent and hard work.

Kadmabini seems to have had received very little respect for her work in her lifetime. Bengali Science Council celebrated Kadambini's 150th birthday. The director Sohini Sengupta had played the role of Kadambini in Nandikar production 'Rani Kadambini'. In this play an attempt was made to shed some light on Kadambini's life. According to Nandini, the women's liberation movement of Kadambini was not against men or excluding men because she held the belief that men and women can work together, hand in hand!

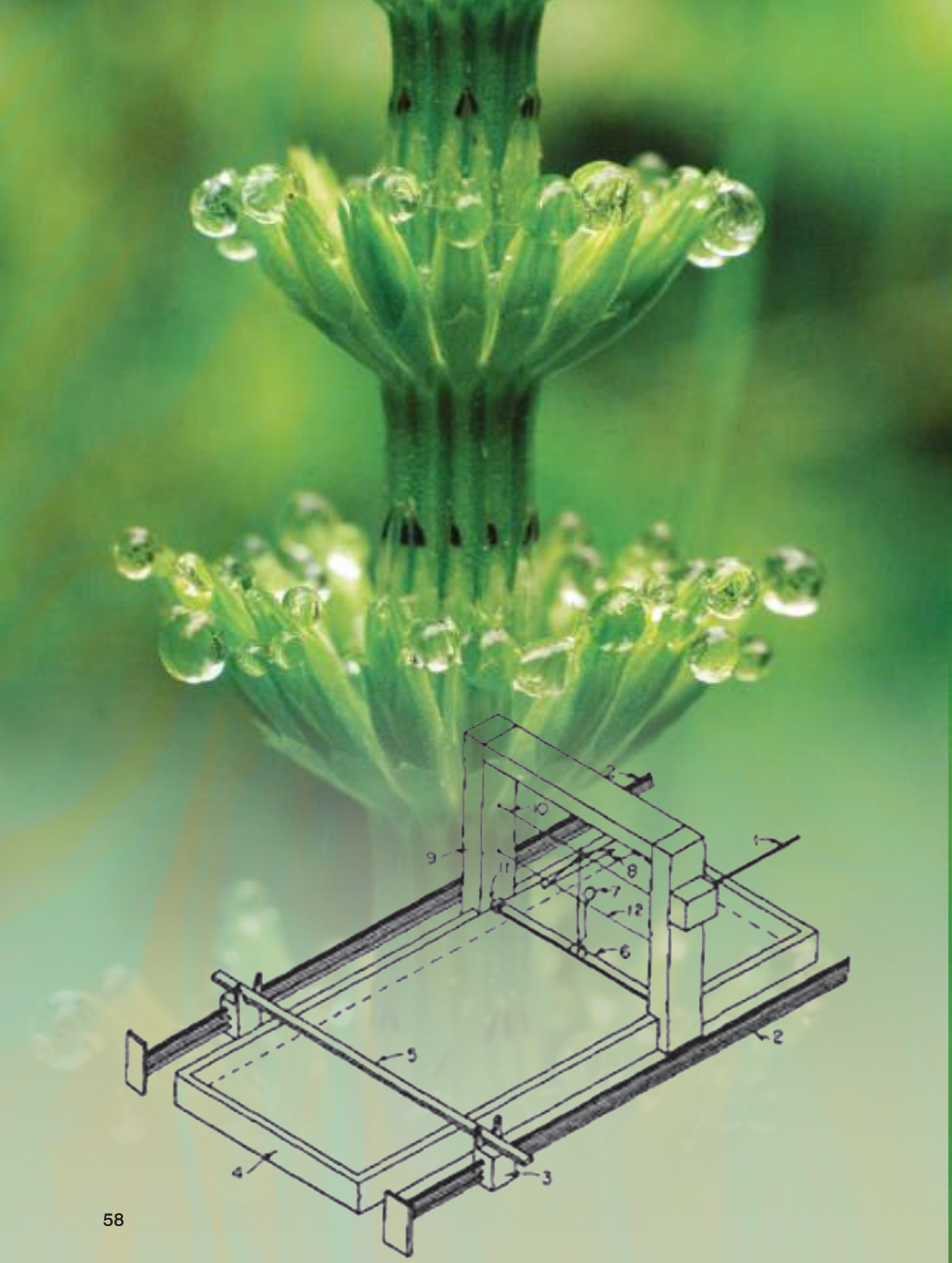
Agnes Luise Wilhelmine Pockels

My own chosen lonely path ...

(1862 – 1935)

Agnes Pockels, a simple girl with no education beyond school used to do all the household chores like cleaning the house, washing the utensils and so on. Deprived of university education, her interest in science instigated her to read her brother's physics books. While washing the dishes she was intrigued to see soap bubbles, their formation, assembling and bursting and the effect of dirt and different oils on them. She carried out experiments in the kitchen basin or the washing trough. This later laid the foundation of Surface Physics and chemistry as well as Langmuir-Bloddget thin films deposition technique.

CHAPTER TEN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Italy is well known for some of the most beautiful cities in Europe. City of Venice in the north of Italy is also a charming city build in Adriatic sea lagoon. There are canals all over the city and seawater around the city. So malaria infection is very common in the city! A regiment of the Royal Austrian Army was stationed in Venice. Agnes Pockles' father was an officer in that regiment and her parents were living in Venice when Agnes was born on February 14, 1862. But in 1871, there was an outbreak of malaria. Agnes' father was stricken with malaria and he had to quit his job. So she returned to her hometown of Brunswick (German-Braunschweig) with her parents and her younger brother Friedrich.

Brunswick is a city in northwestern Germany. It was a prosperous city at that time. Agnes was educated at a local municipal school. At a very young age, Agnes had a big responsibility of everything from cooking to cleaning the house, as her parents were ill. Even so, Agnes studied well at school. She was known as a very intelligent student in school. She was fond of natural science and was brilliant at it. After finishing school, she wanted to go to university and study science. But in the 19th century, women were not given admission in German universities, and her parents did not want her to struggle for it! Agnes did not even get married, perhaps because of her old parents who were constantly sick. She spent most of her time caring for her parents and taking care of household chores. So she could not find time to go out or discuss issues with others. She was a simple, good-natured girl and her parents and brother were her whole world! Still, her curiosity, keen observation, and her love for science did not wane. Fortunately, her brother was studying science at the university. He later obtained the doctorate in 1888. Agnes loved to read his physics books. She was fascinated by the soap bubbles that she saw while washing glassware in the basin or trough and the oil floating on water. It is common to use soap in washing dishes but nobody had bothered about soap bubbles, how are they formed, grow and burst! Scientific literature about soap bubbles or oil deposits was not available. Now books have been written on kitchen science too! It is now possible to give scientific answers to many questions like why mustard crackles and cumin seeds sound different when put in hot oil. It is possible to give scientific answers to many questions such as whether it is better to cook in a stainless steel pot or in a copper pot. But things were different at the time of Agnes. In the 18th century, scientist Benjamin Franklin recorded that even a small amount of oil spilled on turbulent seawater, calms the water waves over long distances. But no one knew why. Agnes did not get to read anything on soap bubbles and the effect of oil.

Agnes was only 18 years old when she started some experiments in the kitchen! She took a rectangular trough and placed a metal strip slider, as well as a small light about a button size metal disc, which was tied to a scale using a thread and just released into the water. The slider was used to divide initial water surface into two parts. The scale could measure the force on metal disc. When a small drop of oil was dropped into the water it spread and formed a thin film. As can be understood now, the oil molecules spread on water loosely. When the slider was moved surface area of water with oil film changed. When area was large, metal disc floated on water with oil. But as she kept on slowly moving the slider (say from right to left) to reduce the water surface area with the oil film on it, interesting things started happening. When the area was reduced, at some stage the metal disc was lifted! This happened because the oil molecules had started pushing each other. Through the light metal disc dropped in oil, the change in force could be measured. With further reduction of surface area the molecules even climbed on each other! The change in surface tension (force) due to the density of the oil could be obtained by changing the area of the oil on the surface and the force could be measured with the scale attached to light metal disc.She noted that the surface tension was decreasing with concentration of oil. She also found in her experiments that different types of oils like sunflower oil or olive oil and soap changed the surface tension. Dirt content also made a difference in surface tension of various films of organic molecules. She did such experiments in the kitchen for ten consecutive years. She had no idea that she was doing something new and actually writing an important chapter of surface science and surface chemistry! Agnes' experiments laid the foundation for the subject of surface tension in science!

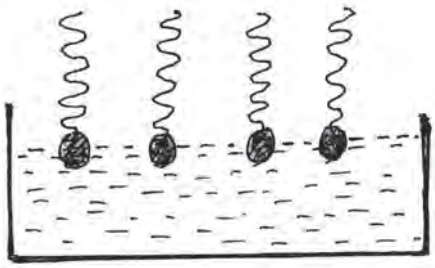
At some point, Agnes came to know through her brother that Lord Rayleigh was engaged in a similar experiment in England. Lord Rayleigh was an eminent

Pockels' balance – a simple but accurate way to measure surface tension

scientist of the time. He had carried out significant research on how scattering of light occurs. There was no acquaintance or any scientist through whom she could correspond with Lord Rayleigh. She wanted to corroborate her work and seek his opinion on it. She wondered whether a great scientist like him would read and comment on her kitchen experiments! Finally she mustered the courage and wrote a letter to him along with the details of her experiments. She also urged him to verify these experiments. She wrote it all in German because she did not know English. Fortunately, Rayleigh's wife knew German very well and translated the letter. Lord Rayleigh realized the importance of Agnes' work, and also was convinced about their authenticity. Agnes in her honesty and simplicity had written to him about her educational background. But even though she did not have a university degree or higher education, he did not have the slightest doubt about her research. Her work was to some extent confirming his work. The great liberal scientist Rayleigh sent Agnes' work directly to the prestigious science journal *Nature* with a letter of recommendation for the publication. That is how Agnes' ten years of hard work came to fruition! The surface-force (tension) work became famous in her name. It was published in the 46th issue of *Nature*, p. 437 in 1891.

> **"...but inequality of opportunity also has an undesirable, but less quantifiable, consequence: the waste of intellect that stems from reducing the talent pool. Agnes Pockels is an example of one whose contribution was almost lost to us."**
>
> *– Andrea Sella in Chemistry World*

The approval of her work by Lord Rayleigh and its getting published were very encouraging for Agnes. She was excited to do more work in this direction. For the next twenty years, she did very basic research on the subject of surface tension and published 14 research papers in *Nature*, *Science* and other important scientific journals of the time. She also translated a scientific book. However, from 1902, her work stopped due to domestic problems. First her father died in 1906 and then in 1914 her mother also died. She served the two very well until the end. Her brother also died in 1913. Agnes became very lonely. That was the



beginning of the First World War. Everywhere there was poverty and sorrow. Fortunately, Agnes had invested some money with her relatives in the state of California (USA). So she did not have much difficulty in living moderately. Otherwise the situation in Germany was very miserable.

In 1917, Irving Langmuir, a scientist in United States of America further developed Agnes' trough and carried out detailed investigations of organic monolayers. Langmuir received Nobel Prize in Chemistry in 1932 for his work. In the 1930's Langmuir and his colleague Bloddgate at the General Electric Laboratory in the United States of America used Agnes' trough to transfer multiple layers (monolayers, one over the other) on solid substrate. Even today, computer-aided improved trough is used to study organic and polymer molecules as well as their monolayers and multilayers. But the technique is now known as Langmuir-Bloodgate technique! In fact, even the scientists of that time said that Agnes' research was the basis of Langmuir-Bloodgate's work! But just because there was no education, she did not go to any conferences and people did not know about her. Agnes Pockles remained neglected due to her unfamiliarity. Perhaps due to this reason she could not get the Noble Prize. In her own country, Germany also she did not receive much attention, publicity or awards until her death. In 1931 she was given the 'Laura Leonard' award which was shared with Henry Devaux. In 1932, at the age of 70, Carolina Wilhelmina Brunswick University awarded honorary doctorate to Agnes Pockles. On her 70th birthday, the famous chemist W. Ostwald reviewed her work in her honor and wrote, "She not only taught us cleanliness at work, but also taught us how to measure it"!

After 1902, Agnes could not do much new work. Because of the war, she could not get access to any literature. Eventually, her eyesight also deteriorated. However, the last research paper on some of her old experiments was published in 1933. She spent the last days with her friends and in social work. She died in Brunswick on November 21, 1935, at the age of 73. Since 1993, the Technical University of Brunswick has started awarding the 'Agnes Pockles Medal' for outstanding work to a female scientist.

> **I often wished I had a formal education after I was 15 years old, but it was not to be. Instead, I pursued my studies entirely alone. The fact that the science community accepted my work makes all the hours of lonely work a true triumph.**
>
> *– Agnes Pockels*

Annie Jump Cannon

LITTLE, LITTLE, LITTLE, STAR ...

(1863 – 1941)

Annie Jump Cannon was a female scientist who had alone counted about 350,000 stars. Together with Edward Pickering, she developed the Harvard Classification Scheme for stars. The method of classifying the stars created by her is still used today with slight modifications. When she was young Annie became deaf due to some illness. However, she did not give up the interest of observation of stars. She was considered as one of the greatest female astronomer of her time. She was also known as an active member of the 19th-20th century American women's movement, the Suffragist and the National Women's Party.

CHAPTER ELEVEN

Annie was a phenomenal astronomer. At the Observatory Group at Harvard she was tasked with classifying stars based on a huge catalogue of astronomic spectrography. Annie soon realised the inadequacy of the system and developed her own system. By 1910, Annie's system had become the de-facto standard, and, with minor modifications, remains so to this day.

Annie Jump Cannon was born in Dover, Delaware, USA. Her father, Wilson Cannon, had a shipbuilding business. He also held the prestigious post of 'State Senator'. Her mother was Mary Jump. The Canon couple had three daughters. Annie was the eldest. She was born on December 11, 1863, in Dover, Delaware. Her mother nurtured in Annie a love for astronomy since her childhood. Her mother loved astronomy and knew a great deal about stars. She introduced Annie to some stars, and constellations at an early age. Thus, Annie received her first astronomy lessons from Mary. Annie became interested in gazing at the sky. She used to keep the lantern in the attic and climb on the roof of the house whenever the weather was good and the sky was clear. She used to carry a notebook to record the stars while watching them at night. Her mother helped her in identifying planets and stars from an old astronomy book. Annie pursued this hobby whole heartedly. But her father feared that at some point of time the lantern might set the house on fire! But that did not happen. Her father used to breathe a sigh of relief in the morning when he would see the house safe!

Annie was educated in Dover. She completed her schooling in 1880. She was then admitted to Wellesley College in Massachusetts. Wellesley was known at that time as the best college in the country for girls. Annie's mother encouraged her to learn mathematics, biology and chemistry. For college education, Annie lived in the hostel for girls. Even there, she pursued her interest of sky observation. At night, she would put the lantern in the window of her friend's room and sit on the roof to observe the sky. Once, however, she saw a lot of smoke coming out of the window. Annie came downstairs and saw that all the furniture in the friend's room was on fire! The fears of Annie's father came true somewhere, sometime. Even after this incident, Annie's obsession with sky observation did not abate. In 1884, Annie graduated with a degree in physics. In college, Annie was regarded as an intelligent budding student.

After completing the college education, Annie returned to Dover, Delaware. She lived there for about ten years. During that time she learned the techniques of photography. Annie widely used photography techniques in her later research. She also used it on a trip to Europe in 1892. The photos taken in Spain using the Blair Box camera, were printed by the Blair Company and using them some pamphlets were made under the title 'On the Footsteps of Columbus'. They were distributed in Chicago and also at an exhibition on Columbus in Chicago in 1893. Annie fell ill and after this and became deaf due to a contagious 'scarlet fever'. As a result, she could not freely move in society and began to spend more time alone.

> **A life spent in the routine of science need not destroy the attractive human element of a woman's nature.**
>
> *– Annie Jump Cannon*

But her observations of the sky and her study increased her concentration.

Annie's mother died in 1894. She started feeling lonely at home. So she started a job of teaching physics as a junior teacher at her old Wellesley, Massachusetts College. She could also study astronomy and spectroscopy subjects there. She took admission in the Radcliffe College as a 'special student'. Her intention was to use the telescope available in the Radcliffe College. The college was for women and was near the famous Harvard University. The professors at Harvard University also taught at Radcliffe College. So Annie got a chance to visit the Harvard University Observatory. From Annie's point of view, this was a golden opportunity. Later in 1907, Annie completed her Masters degree in Physics from Radcliffe College.

In 1896, Edward C. Pickering, a professor at Harvard, had noticed her interest and agility in astronomy. Pickering hired Annie as his assistant at Harvard Observatory. Professor Pickering was compiling the 'Henry Draper Catalogue'. Anna Draper had provided the financial support to the 'Henry Draper Catalogue'. She was the widow of Henry Draper, a very wealthy and amateur astronomer. For that work Pickering had employed the girls from Radcliffe College and formed a group of them. It was planned to record all the stars in the sky and also to classify them. The stars were to be numbered as 1, 2, ... up to 9 according to their intensity (1 is the most intense, 2 after that ... 9 the least intense). But the task was not as simple as it seemed. According to Professor Pickering, no one could do this job very quickly. It would not be possible to classify the stars simply by their intensity. It also required the separation of light coming from the stars using spectroscopy technique. Studying the stars in this way was unique at that time. Professor Pickering decided to use this method. So after studying a lot of stars when they were classified, it helped to predict the temperature of the stars and therefore the condition of the stars (new formation or aged or dying). Annie herself classified about 350,000 stars. By taking photographs of the stars, and using magnifying glasses, stars having more than 9 number intensity (up to 11) could be seen by her microscopic vision. Her observations were very accurate and others agreed with it. No one has made such a great observation till date! Seeing the benefits of using her classification methods and photography technology as well

as spectroscopy, other scientists followed her suit. With some modifications, the classification method she developed is still used today. This was Annie's greatest contribution to astronomy.

In 1921 University of Groningen in the Netherland awarded her an honorary doctorate. In this way, Annie started getting international recognition. In 1922, the International Astronomical Union officially approved her method of classification of the stars. In 1922, she spent six months in Peru in the southern hemisphere observing the sky. The Henry Draper Catalogue, also known as the Star Encyclopedia, was published between 1918 and 1925 in a total of nine volumes. Two lakh twenty five thousand three hundred of total 1 to 9 intensity (2,25,300) stars are recorded in it.

In 1925, she became the first woman to receive an honorary doctorate from Oxford University. In 1929, the League of Women Voters named her 'The Great Living American Woman.' In 1931, she was awarded the Henry Draper prize. She was the first woman to receive this prize. In 1932 she also got Ellen Richards Prize.

Annie Jump Cannon examines a photographic plate of the night sky

She received her third honorary doctorate in 1935 from Oglethorpe University in Brookhaven, USA.

In 1935, she herself instituted an 'Annie J Canon' prize for woman who excelled in astronomy. A woman from any country irrespective of her age is eligible for this prize. Annie was constantly working. In 1949, Annie published a supplement to the Henry Draper Catalogue. It records stars with as low as 11 number intensity. So a total of three lakh fifty nine thousand and eighty three (3,59,083) stars were recorded in the catalogue. Most of the credit for the record of such stars goes to Annie. It was made possible by the hard work of a woman like Annie! From this account one can imagine the huge contribution of Annie to astronomy. She was the first female officer to be elected to the American Astronomical Team. She was also an active member of the international suffrage movement for women's rights. Women in England, USA and many other countries had no education, voting rights or equal pay as men. They were deprived of such fundamental rights. Therefore, at the end of the 19th century and for some early years of the 20th century, the women's organization 'Suffragist' was working. She was also an active member of the National Women's Party in the United States. They staged various rallies and she used to attend their meetings.

Annie died on April 13, 1941, in Cambridge, Massachusetts, at the age of 77. She was working till the very end. After her death, her memory was preserved in various ways. The residence of the president of Wellesley College, the college where she studied, was named 'Annie Jump Cannon House'. A crater on the moon was named 'Canon'. An asteroid is named after her. There is no doubt that Annie Jump Cannon was an illustrious scientist who was deaf, but overcame her illness and did a great job in the field of her interest.

Pickering (back row, third from left) with the Observatory Group of Harvard College, 1911. Annie Jump Cannon can be seen in the back row, fifth from left, who at that time was about halfway through classifying stellar spectra for the Henry Draper Catalogue.
(Credit: Harvard University Archives, W360663_1)

Rakhmabai Raut

FIGHT AGAINST CHILD MARRIAGE ....

(1864 – 1955)

Rakhmabai was married at the age of 11. As per old Indian tradition she continued living with her parents. Meanwhile she developed interest in education and wished to become a doctor. By the time she was supposed to move to her husband's place a huge gap at the mental and cultural level had developed between the two. According to Hindu laws a married women could either live with her husband or go to jail. Rakhmabai preferred the latter. After Anandibai Joshee, she is the second Maharashtrian woman to become a doctor who rendered service to her patients almost till her last breath.

CHAPTER TWELVE

Dr Rakhmabai's childhood home in Gamdevi
(Credit: timesofindia.indiatimes.com)

British came to India and their customs and ideology began to affect Indians, especially the younger generation in the cities of Calcutta and Mumbai. A new class of learned reformers and fashionable youth, trying to imitate the English, were slowly emerging. Harishchandra Yadavji Chaudhari, who was in the government service in Mumbai, was a reformist, a little bit under the influence of the British. His eldest daughter's name was Jayantibai. He had taught her to read and write, but in 1863, at the age of 15, she was married to Janardhan Pandurang Sawe. Janardan was a budding young man who was a contractor in the construction business. Jayantibai and Janardhan's life was going on well. After one year, on 22nd November 1864, a daughter was born to them. They named her Rakhmabai. Unfortunately, Janardan died soon after Rakhmabai was born. Janardhan did not have any brother and his sisters had got married. As Jayantibai was left alone at home, Harishchandra Yadav brought Jayantibai back to his house with her infant Rakhmabai.

Harishchandra Yadav was a reformer who did not like his young daughter to remain a widow all her life. So he was in search of a suitable match for Jayantibai in his caste. He soon saw an eligilble man, Sakharam in his thirties. Sakharam Arjun Raut was a modern doctor who liked Harishchandra and Jayantibai. Sakharam Raut himself was a widower and did not want to marry a very young girl. Hence the marriage of Sakharam and Jayantibai was fixed. He was also happy to have Jayantibai's little girl. Fortunately, in their caste, such a marriage was allowed. So in 1870, Sakharam and Jayantibai got married and Rakhmabai at the age of six started living with her mother and stepfather. Rakhmabai now became 'Rakhmabai Raut'.

Dr. Sakharam Arjun Raut was well to do and liked to wear elegant, fashionable clothes. He lived lavishly but was well mannered. Being highly educated himself and moving among the cultured, educated society, he also had a view to treat women well. He had arranged for Jayantibai and Rakhmabai to be taught English at home. Dadaji Thakur, the son of a woman from Jayantibai's relatives, was only 5 years older than Rakhmabai. There was a suitable age difference between the children for marriage as at that time. At the insistence of Dadaji's

> **This wicked practice of child marriage has destroyed the happiness of my life. It comes between me and the things which I prize above all others – study and mental cultivation. Without the least fault of mine I am doomed to seclusion; every aspiration of mine to rise above my ignorant sisters is looked down upon with suspicion and is interpreted in the most uncharitable manner.**
>
> *– Dr Rakhmabai*

mother, Rakhmabai and Dadaji got married when Rakhmabai was 11 years old. Jayantibai and her father Harishchandra Yadav thought that the boy would get good education and would be raised properly as time passes by. Sakharam Raut being a stepfather preferred to remain neutral. However, it was decided that Rakhmabai would stay with her parents for a few years as she was young.

Sakharam Raut was a professionally skilled doctor in the medical field but he had a special interest in botany. Some of the books on the medical subjects written by him were very popular. He was involved in the work of many organizations in Mumbai. Many doctors, government officials, lawyers, judges, social reformers, Indians and foreigners used to visit his house. Rakhmabai had closely observed the good manners of those people. The cultured atmosphere at home was having a positive effect on Rakhmabai. Her husband Dadaji on the other hand had the opposite influence. After their marriage, when his mother died, he moved in with his maternal uncle. However, his maternal uncle was a wrong influence and was neither educated nor he cared for it. This affected Dadaji who consequently had similar friends as his uncle and did not get good upbringing. Once in a while he used to go to Sakharam's house. At that time, Rakhmabai's family was trying to persuade him to learn. But Dadaji's behavior did not change. He started urging Sakharam to send Rakhmabai to him to his (?) house. Rakhmabai was not ready to go to the one who was living with his uncle like a dependent person, who was not educated and who was in a bad company and environment. She had seen around the physical and mental hardships caused by the early marriage of her friends and other women. Although reformist social workers had succeeded in enacting a law requiring girls to be at least 10-11 years of age for child marriage, girls used to be young in all respects. They were physically immature and did not have the ability to make their own decisions.

Besides, at the age of 13-14 they would start having children and were forced to work at home. Moreover, due to the social custom of talking to a stranger, not even touching men, even during delivery or even when women had chronic illnesses, they could not get medical help. As a result, they along with their children suffered greatly. Often, their lives were in jeopardy. Seeing all this, the wise Rakhmabai wanted to learn and become a doctor like her stepfather. Sakharam and Jayantibai concurred to what Rakhmabai thought. Knowing it, Dadaji got angry, went to Raut's house and started arguing. But Sakharam stood very firmly by Rakhmabai. Dadaji's uncle also stepped in. As a result, in 1884, Dadaji filed a case under the Hindu Marriage Act (marriage restitution act) in the Mumbai High Court against Rakhmabai for conjugal rights.

The case of Dadaji versus Rakhmabai echoed not only in Mumbai but in the whole of Maharashtra. Its repercussions were felt in the country and in Britain as well. Already the movement against the tradition of sati, prohibition to widow remarriage and child marriage had only begun in the 19th century. Both Sanatan and progressive classes used to quarrel over these issues. Some of the great leaders did not like the refusal of a married girl to go to her husband. Articles after articles started appearing against Rakhmabai, her mother Jayantibai and father Sakharam along with grandfather Harishchandra Yadav. Dadaji made allegations that Rakhmabai's family was not sending her as they were greedy for the estate

Illustration depicting Rakhmabai arguing the case against child marriage which became the precursor for the 'Age of Consent Act, 1891'.

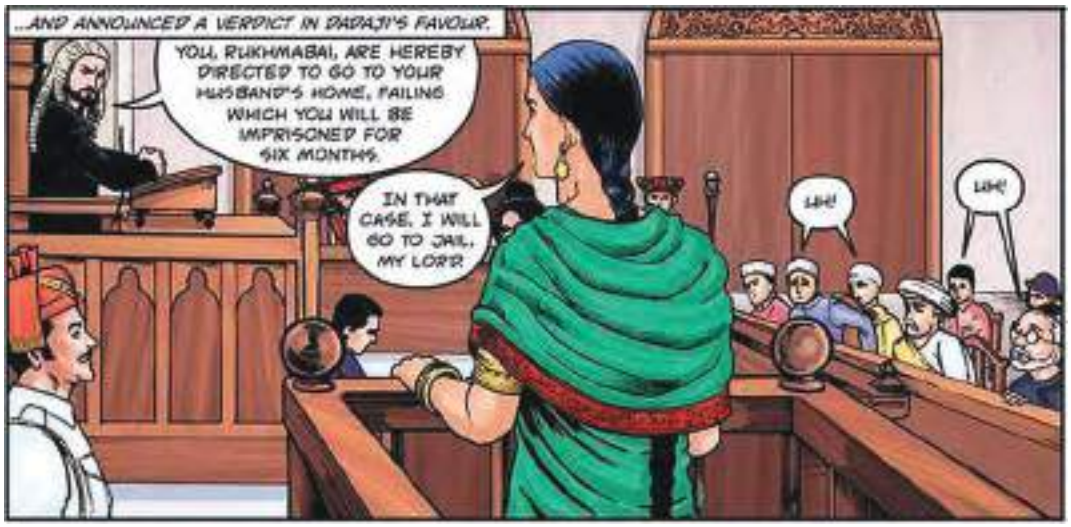
(Credit: https://artsandculture.google.com/story/dr-rakhmabai-zubaan/2QUxW4kD5ASAJg?hl=en)

of Rakhmabai's biological father. Rakhmabai was very firm about her decision and was not intimidated. When a Hindu girl tried so hard to learn, people around her and traditional people were not convinced by her motivation.The society did not like that instead of convincing her, Rakhmabai's family was supporting her in her decision. The society boycotted her family. When Rakhmabai would pass by people would throw stones and garbage at her. Sakharam developed diabetes at the age of 45 due to mental stress and died prematurely in 1885. Jayantibai and Rakhmabai lost a strong support. Rakhmabai and Jayantibai were now mentally and financially dependent on Rakhmabai's grandfather. He supported them in those hard times and did not compel Rakhmabai to go to Dadaji.

A few months after Sakharam's death, court gave the judgement that Rakhmabai could not be forced to go to her husband. The reformers thought that Rakhmabai had won the battle but that happiness was fleeting. Dadaji, Sanatani Hindus and his supporters prepared thoroughly for the next war. Even a leader like Lokmanya Tilak began to feel that the British government was interfering in Hindu religious customs. Rakhmabai was again criticized in the newspapers. But Rakhmabai had also decided not to give up at any cost. According to the law of the day, if she did not go to her husband, she could face imprisonment. But rather than going to an uneducated, weak husband, Rakhmabai was ready to serve the sentence of imprisonment! She started writing letters in the Times newspaper under the pseudonym 'Hindu Lady', describing the plight of women at that time and against the social oppression against them. She took the nickname only because she did not want anymore to bother her family members because of her. Of course, people knew who this 'Hindu Lady' was! Dadaji or Rakhmabai, none of them could really afford the lawyers' fees, disgrace and mental anguish that was taking place in the society. Even great socialists like Pandita Ramabai and Justice Govindrao Ranade sided with Rakhmabai. To help her, an English woman created a fund called 'Hindu Lady Fund'. Unfortunately, in 1887, the court's decision was now in Dadaji's favor. Although Rakhmabai was emotionally right, according to the Hindu law of the day, Dadaji had the right to take Rakhmabai with him but could not force her. Rakhmabai was preparing to go to jail. But it was alleged by Dadaji that the court deliberately did not order her arrest. Additionally, Dadaji filed a defamation suit against Rakhmabai and her grandfather Harishchandra. In all these cases, Dadaji and his uncle got a lot of disdain in court. On some occasions, his lies also came to the fore. Moreover, Rakhmabai's determination and firmness startled him. As a last resort, Rakhmabai could go to the 'Privy' court. The 'Privy' court was in England and the citizens of the British

Empire had the right to appeal there against the decision of the High Court. The 'Rakhmabai Samrakshan Samiti' an organization to support Rakhmabai was set up and she received donations by many broad minded people. However, the trial would have been held in England and this cost was certainly not affordable to Dadaji. Besides, he was convinced that even if Rakhmabai came to him, she would not listen to him and she would be dominant and adamant. As a result even though there was no legal divorce in the end, Dadaji agreed to separate from her. Thus, Rakhmabai's path became independent.

Although Rakhmabai did not win legally, the whole Hindu society was stirred by the atrocities committed against women. She made people think about it. Rakhmabai fought an unprecedented struggle in favour of women's desire to get scientific education and for them to have that right. After reading this, one would think that Rakhmabai must be a haughty, rebellious woman who did not want to follow the rules of religion. But Rakhmabai's fight was for women's freedom. She wished that like men, women also should be able to get the education they wanted and be able to progress themselves in the society. Rakhmabai, who grew up in the company of cultured people like Harishchandra Yadav, Sakharam Raut and Jayantibai, never forgot that she was married. She was freed, and even though Dadaji remarried, she never thought of remarrying. She used to wear a colorful traditional Maharashtrian nine yard saree when she went to study in England and used to have a red kumkum on her forehead. Later, when Dadaji died in 1904, she stopped wearing kumkum and colorful sari, according to the



(Credit: Women Path-Breakers: Amar Chitra Katha, Stories of Success and Strength, Illustration by Sanjay Valecha, R Rukhmabai)

Hindu tradition. She started wearing only a white sari! By her actions, Rakhmabai became a role model and ignited the flame of women's freedom in the minds of the women of her time.

The British government could not afford to take Rakhmabai's side in the Dadaji-Rakhmabai case and hurt the feelings of majority Hindus and their leaders! But many British people living in England supported Rakhmabai. Some were even willing to help her if she went to England for education. Lady Eva McLaren and Sir Walter McLaren, who lived in London, had read a lot about Rakhmabai. They gave her an invitation to come and stay with them. The 'Rakhmabai Samrakshan Samiti' decided to help her financially. Due to her lawsuit and the abusing articles in the newspapers it would have made it difficult for her to stay and study in India. Even in a country like England there were not enough women in the medical field, but the situation was more grim in India. So going to England to become a doctor was going to be the right thing to do in all respects. Only after she promised her grandfather that she would not change her religion and not eat beef, he allowed her to go to England. Jayantibai herself was a modern thinker and she too had suffered a lot in her daughter's struggle. So she said goodbye to Rakhmabai with a smile but was little sad thinking that her daughter would go away. She believed that her daughter was taking a step towards progress and that her rites would always guide Rakhmabai.

When Rakhmabai arrived in England after a four-month ship trip the McLaren couple came to the port to fetch her. They were very rich, distinguished and progressive thinkers. Sir McLaren was a Member of Parliament and Eva McLaren worked in a number of women's organizations. Their spacious and very comfortable house was very close to the Parliament. The house had many rooms and servants for all the work. They used to have many famous people as visitors. The McLaren family, became Rakhmabai's guardians and she stayed with them until her medical college started. Later she used to live with them during her vacations in England. They treated her like a member of their family. She was provided a separate room to stay. The high standard of living of the McLaren family went well with their good manners and Rakhmabai was comfortable with them due to her humble, courteous demeanor and her idealism. Along with Eva McLaren, Rakhmabai attended some women's meetings and discussed Indian women's issues. Her speeches, her humble behavior, and her passion for women's problems were well-received in England. In this way Rakhmabai was accommodated by the local society. She was also making good use of that opportunity. In England as a whole Rakhmabai made her thoughts more profound by interacting with many reformist women.

Of course, becoming a doctor was Rakhmabai's primary goal. She enrolled in the London School of Medicine for Women. In October 1890 she moved to the nearby College Hall, a university dormitory for girls. There she spent four years. After passing the first year examination in 1891 and the second year examination in 1892, Rakhmabai undertook practical training in the third year at the Royal Free Hospital. She was trained as a midwife and trained in gynecology for two months at Rotanda Hospital in Dublin. She also completed her dental course at the National Dental Hospital. She studied ophthalmology at Murfield Ophthalmic Hospital in London. She also got trained for a few days at Alexandra Hospital for Children with Hip Disease. Thus Rakhmabai successfully completed various courses at the London School of Medicine. She passed the operative midwifery examination of obstetrics and gynecology. However, according to the law of the time, the London School of Medicine could not give her (a woman) a degree! For that she had to go to Scotland and take the examination. Like in India, England at that time also was fighting for equal rights for women and education! Rakhmabai finally left Scotland in 1894, Graduated and next to her name was LARCP & S the title of these degrees was shown! Rakhmabai's name appeared in the medical register of England and she could pursue a career in medicine.

The London (Royal Free Hospital) School of Medicine for Women from where Dr Rakhmabai completed her MD in 1894

Rakhmabai returned to Mumbai in December 1894. Kama Hospital was being set up in Mumbai from Dufferin Fund. (Similar to Kama Hospital, some branches were later opened up from the Dufferin Fund at Surat, Baroda, Delhi, Madras (Chennai) and are still operating there). There, in February 1895, she was appointed House Surgeon. But it was a temporary job. Plus a lot of people had not forgotten the story of her trial. So when she saw an opportunity to work at the newly started Malvi Hospital in Surat, created from the Lady Dufferin Fund, she grabbed it. It was definitely good for her to get away from the atmosphere of Mumbai. Besides it was to be a hospital specifically for women, and her degree as a gynecologist and obstetrician would be put to good use there. Taking on the full responsibility of the new hospital would also add to her experience. Rakhmabai was appointed as a medical officer there in November 1895 and immediately after that she left for Surat in December 1895.

Rakhmabai was given the entire responsibility of running the Malvi Hospital. Initially, the hospital was started at Malvi's house in Gopapura area. There were no other doctors to help her. The cornerstone of the hospital building was installed in the same area in1895 after the construction of the building, Rakhmabai moved there. Earlier, she rented a room near by. It was necessary for her to be in harmony with the environment so as to gain the trust and confidence of the local people. So she started wearing Gujarati style sari instead of wearing Maharashtrian style nine yard sari. Gradually, her house became the hospital and the hospital became a home! Initially, the women were not ready to come to the hospital. Whether poor or rich, traditionally the delivery would take place with the help of (usually) untrained midwife as per their procedure! This would be at home in a dark room with low ventilation! In some places it was customary for women not to touch anyone in the house for 10 days after delivery and in some places for 40 days. So it used to be a nightmare for women who were already undergoing the trouble while giving birth. Moreover, in those days it was customary for women delivering a child to not to touch the wood. When Rakhmbai started practicing at first they would have to make the delivery on the ground. Rakhmabai had to sit on the ground in the same position for a couple of days. The delivery would take place in a dark room.

Rakhmabai started urging women to get admitted in the hospital. But the traditional society was skeptical of admitting women to hospitals. Therefore, creating awareness among women was the first challenge for Rakhmabai! She went from house to house trying to persuade women. Still, people were worried that if women gave birth to a child in a new hospital, it would be a bad omen,

and no one was willing to take the risk. One day Rakhmabai saw a pregnant goat and an idea came to her mind. She took the goat to the hospital where she gave birth. Rakhmabai published this news in the newspaper. After reading it, the doubts about hospital safety in the minds of the people gradually disappeared and women started coming to the hospital. The softness of Rakhmabai's demeanor and speech, affection and cleanliness in the hospital began to be seen by the women and it was spread everywhere that it was better to go to the hospital for delivery. Sometimes children would come along with their mothers. Rakhmabai also started a school for them called 'Malvi Balak Mandir'. There she taught in the afternoon.

Rakhmabai wished to start a nursing course for women but there too she had to face a lot of difficulties. Rakhmabai realized that it was very important to teach hygiene to women. They need to be taught that if they learn to be clean, they can take care of their children and their families, and they can control the disease. But the men of the house did not allow the wives to go out, forget about going for nursing classes. Rakhmabai came up with a solution! Women could get out of their houses for religious reasons. If gathered this way, there would be no obstacles. So she began to gather women on religious occasions. Gradually, she started teaching them embroidery, weaving, reading, cooking and hygiene. She did not know when she became 'Bai (In Gujarathi it means elder sister)'! Rakhmabai developed close ties with men, women and children from the high and low caste,

Dr Rakhmabai writes against child marriage to Times of India on June 26th 1885 under the pseudonym 'A Hindu Lady'
(Credit: https://artsandculture.google.com/story/dr-rakhmabai-zubaan/2QUxW4kD5ASAJg?hl=en)

from rich to poor, Hindus, Muslims, Parsis. She used to participate in programs of many social organizations in Surat. Her relatives in Mumbai and their children used to visit her in Surat on holidays. At such times, she was happy to cook for them and feed them by her own hands. There was no time for Rakhmabai to feel lonely because of her busy schedule. She used to be always surrounded by many people and she was setting an example for them through her own behavior. She became a role model for many women. Rakhmabai's work made a good impression on the community in Surat. At the age of 50, in 1917, she retired from the job. But the hospital in Surat where she was working is still known as 'Rakhmabai Hospital'. She has been mentioned in 'Surat Sonani Murat' among the distiguishd people who contributed to the development of Surat.

As such, the age of 50 is not much. Besides, her capacity to work and enthusiasm were also very good. There was a need for a female doctor at Rasulkalji Janana Hospital in Rajkot. Rakhmabai joined there in 1918. She adjusted easily in the local society and kept on striving for the upliftment of women. She also treated virgin mothers, widows, troubled women and tried to make their lives better and happier by letting them do what they liked in reading and writing or doing household chores. She handled the problems of the people around her with great compassion. Along with the medical professional work of a doctor she carried out a great deal of social work. She showed the way of progress, the way of living a healthy life in a modern way. Where many young men and women today do not care even for their own parents, it comes to our mind, how Rakhmabai cared for the very people who had treated her very badly at her young age! Only a kind hearted person like Rakhmabai could do this.

Rakhmabai returned to Mumbai in 1930 at the age of 65 after completing a prosperous career in Rajkot, leaving behind numerous grandchildren (!). She had taken a house near her mother Jayantibai's house at French Bridge in Mumbai. She started living there from 1931. Even at that age she used to teach the surrounding children, adults, standing up against untouchability, lecturing on women's issues and health in many places. She was working till the end. Rakhmabai died on December 25, 1955, at the age of 91. Without any regrets in life she utilised her medical knowledge for her own country.

Google Doodle in memory of Dr Rakhmabai on her 153rd Birthday on November 22, 2017

Anandibai Joshee

INDIA'S FIRST FEMALE DOCTOR

(1865 – 1887)

A girl born in Pune in the maternal home on March 31, 1865 to an ordinary Maharashtrian family, went abroad at the age of 18 and became the first woman doctor of India at the age of 21. She or her parents had not even dreamt that she would become a doctor sometime! But Anandibai Gopalrao Joshee, who became a doctor after enduring hardships, could not serve Indian women. She died at the age of 22, yet she was and still is a source of inspiration for many Indian women.

CHAPTER THIRTEEN

Top: Women's Medical College, Pennsylvania

Bottom: Anandi Gopalrao Joshee during a class at Women's Medical College of Pennsylvania in 1880s

Yamuna Joshee, a young woman from Kalyan village near Mumbai, who was only 9 years old, was married to a 30-year-old widower named Gopalrao Joshee. It was the time that she should be playing with other children but in the 19th century a girl of the age of nine was considered too old for marriage. Besides, Yamuna was an ordinary looking girl and also appeared a little older than what she actually was. Although born in a high breed brahmin family, she was very ordinary looking. Her height was just five feet. Even though her family was once rich, the financial condition of her father was not good. Therefore, her father had decided that the girl should be somehow married to any brahmin! When her father came to know about Gopalrao, a widower, he decided to accept any terms that Gopalrao would impose and get Yamuna married. Gopalrao's main condition was that his wife should learn as long as and as much as he wished. This was a strange condition because women's education was not prevalent at that time. Her father left it to Gopalarao's thinking and decided that it was none of his business what his son-in-law and daughter do after the marriage. Post her wedding Yamuna was named Anandi and she became Anandi Gopal Joshee.

At the time of marriage Anandi had no idea that one day she would become the first woman doctor in India! She must have thought that her husband would teach her to read and write a little. He first started teaching her at home to read and write English. His attempt to enroll Anandi in a missionary school was unsuccessful otherwise, he wanted to teach her there. Gopalrao's father, other relatives or friends did not like Gopalrao's teaching his wife at home, forget about sending her to a missionary school. At that time, husband and wife could not even talk to each other in front of others and Gopalrao used to teach his wife openly in front of everyone! From the point of view of the (Hindu) society at large it was as good as drowning the religion. Gopalrao used to work in the post office and had a meager salary. He was not rich either. In order that Anandi should be able to learn he preferred to get transferred sometimes in Mumbai, sometimes in Nashik and sometimes in Kolhapur. Everywhere conservative people would outcast and trouble Anandi and Gopalrao because of her going to school. Anandi had no choice but to listen to her husband and continue her education inspite of the bad treatment they would receive from the society. Gopalrao was very strict and would become very angry and even beat her if she did not pay attention to the studies or wasted time. Even her spending extra time in kitchen was unacceptable to him.

Although Anandi initially felt troubled, she gradually got absorbed in her studies. Seeing the progress of her studies, Gopalrao wished that Anandi should learn more. They decided that no matter how much the people protested, they will

> **Be grateful for challenges because had there been no difficulties and no thorns in the way, then (each woman and) man would have been in his primitive state and no progress made in civilization and mental culture.**
>
> *– Dr Anandi Gopal Joshee*

not listen to anyone. Gopalrao's father even threatened to stop seeing his face. However, Gopalrao did not waver in his determination. Soon after that, Gopalrao's father died. People used to throw dung or stones at Anandi and Gopal when they passed through the village streets but Gopalrao did not give up his desire to educate Anandi. Finally, Gopalrao managed to get himself transferred to Calcutta where Anandi could get education more easily.

At the age of 14, Anandi had a son. But he lived only ten days. Anandi was very sad. Then she realized that there were no female doctors in India, so women had lots of problems. Women in India avoided consulting male doctors and that is why the death rate of women and newborns was very high in India. By now, Anandi was able to speak and write good English. Gopalrao was also living in a place like Calcutta that was conducive to education. No one knew them very well. So there was not much of an obstacle in her education. Anandi-Gopal decided that Anandi should become a doctor.

In Anandibai Joshee's time, achieving the goal of becoming a doctor by an Indian woman was not an easy task. Nowhere in India did women get admission in colleges. Therefore, Gopalrao wanted Anandi to go abroad and become a doctor. To support her education, Gopalrao even tried to look for a job in the USA. This was not an easy task and Gopalrao did not succeed. He also reached out to some missionaries and sought financial help. In 1880, Gopalrao and Anandi made some correspondence with Royal Wilder, a well-known missionary in the United States, enquiring about the possible arrangements for Anandi's education and his employment. But for that, he put forth a condition for Anandi-Gopal to convert to Christanity! Neither Anandi nor Gopalrao were ready for it. However, Royal Wilder published Anandibai's letter expressing her desire to become a doctor along with her brief resume in Princeton Missionary Review. Fortunately, Theodica Carpenter of New Jersey read Anandi's correspondence, and she generously agreed to take the responsibility for Anandi's education. Gopalrao felt that it would be better for Anandi to go abroad alone and become a doctor. Due to financial constraints they could not afford to go together. Fortunately, along with the studies, Gopalrao also succeeded in inculcating courage in Anandibai by letting her go alone to school in Calcutta or even going alone from Calcutta to her hometown in

> **I regard irreligious people as pioneers. If there had been no priesthood the world would have advanced ten thousand times better than it has now.**
>
> *– Dr Anandi Gopal Joshee*

Maharashtra. She was confident in talking to people and travelling alone. She even spoke in front of a crowd, and explained politely how important it was for a woman to become a doctor. It impressed a large number of people and they made some finance available for her travel to America. This way, Anandibai travelled to the United States in 1883, at the age of 18.

In the United States, Theodica Carpenter welcomed Anandi into her family. It was very difficult at that time to keep a separate identity in a different country, different culture, different dress or different food. But Anandi didn't complain about anything as her ultimate goal was to become a doctor and nothing else could deter her. She became like a member of the Carpenter family. Theodica also helped Anandi in getting admission into medical college in Pennsylvania.

Already there was life threatening cold and she was only wearing a Maharashtrian nine-yard sari dress! The hostel room also was not warm enough. It was beginning to affect her health. Gopalrao had once advised her 'when you are in Rome, you should behave like Romans' or follow the customs there in USA. But Anandibai adopted a middle path. She started wearing Gujarati style sari. So, the belly was covered and the inside petticoat gave her some protection from the cold.

Anandi completed her education with great restraint. The subject of her dissertation was 'Obstetrics among Hindu Aryans'. At the graduation ceremony on March 11, 1886, Anandibai received the title of 'Doctor of Medicine (M.D.)'. Gopalrao Joshee attended the event with a lot of struggle. Anandi's aunt Theodica Carpenter, who loved her like her own daughter, was present at the graduation ceremony. Even, famous Indian activist Pandita Ramabai was present at the graduation ceremony. When Anandibai was introduced as the 'First Female Doctor in India', all the attendees rose to a standing ovation. The Queen Victoria of England, aka the British Empire, later sent a special message praising and congratulating Anandibai.

But this happiness of Anandibai-Gopalrao was very fleeting. Anandi's health was deteriorating. She had to be hospitalized. There she was diagnosed with tuberculosis. But as the disease had not yet spread, she was advised to seek further treatment in India. So soon Anandibai's return journey started. Anyway, she had accomplished the goal for which she had gone to the United States. Besides, she wanted to return to India and help Indian women.

On the way back, Anandi suffered a lot. All the travel was by ship. Plus, it was a long journey. In addition, the doctor on the ship refused to treat the sick Anandi. But on her return to India, Anandi was well received. Kolhapur in Maharashtra then had a hospital called 'Albert Edward Hospital'. Anandibai was appointed as the chief doctor of the women's ward but Anandibai herself needed to be well enough to treat others. Unfortunately Indian doctors also refused to treat her. No doctor was even willing to look at her, because she had broken the rules of the society and crossed the sea! This was the tragic end of India's first female doctor who passed away on 26th February 1887 due to lack of treatment! What could be worse than a doctor dying without a treatment? The society for which she had worked so hard, at least on humanitarian grounds, she should have got the medical help. Her dream of serving Indian women was shattered. But in the process, she succeeded in setting an example of perseverance and hard work in front of Indian women.

Kolhapur's Albert Edward Hospital is now known as Chhatrapati Pramila Raje Bhosale District Hospital. Anandibai's name plate can still be seen there. Part of Anandibai's ashes were requested by Theodica Carpenter. Carpenter's family built Anandibai's tomb on the ashes buried in her family's cemetery. The tomb is in Poughkeepsi, New York. "Anandi Joshee, a young Hindu Brahmin girl. The first Indian woman to get a doctorate by studying abroad" is inscribed on the tomb. A private institute in Lucknow (Institute of Social Science Research and Documentation) (IRDS) has also set up an award for Medicine in her name. The Maharashtra government has started a scholarship in the name of Anandibai Joshee for a young girl studying 'Women's Health'. A few books have been written on her character and a series on Marathi Doordarshan was telecasted a few years ago. Not only that, the American company NASA has named a crater on Venus in honour of Anandibai on her 151st birthday.

Dr Anandibai Joshee's tombstone in New York

Marie Curie

FIRST SCIENTIST TO WIN NOBEL PRIZE IN TWO DISCIPLINES ...

(1867 – 1934)

In the history of science no other female scientist is as famous as Marie Curie. The reason is not unfounded. She was the first woman to win the Nobel Prize in Physics, and the originator of the new term in Physics – 'radioactivity'. She and her husband, Pierre Curie discovered radioactive elements polonium and radium. She worked shoulder to shoulder with her husband. The second Nobel Prize won by her was in Chemistry. She thus became the first woman to win the Nobel Prize in two subjects. In addition, she worked with a number of social organizations.

CHAPTER FOURTEEN

Marie Curie and the President of the United States, Warren G. Harding, coming down the stairs at the White House, 20 May 1921.
Source: Musée Curie; coll. ACJC/Cote MCP198

Born on November 7, 1867 in Warsaw, Poland, Marie Curie was the youngest daughter among five sons and four daughters of the Sklodowska family. Her father Vladislav and mother Bronislawa both were famous teachers of that time. At that time, part of Poland was occupied by Russia, and the Sklodowska family had lost all of their property as a result of participation in the Poland's uprising against Russia. So since childhood Marie and her siblings had to endure many hardships. Everyone had to spend his/her days in poverty. Her parents had to do many other jobs besides teaching in order to support the family. Her mother also ran a hostel for girls. When Marie was ten, her mother died of tuberculosis. Her eldest sister also had died of typhoid three years before her mother. Thus the Sklodowska family also suffered the loss of their family members. Marie was educated in a girls' school and on June 12, 1883, at the age of 16, she graduated with a gold medal. Marie's intelligence was evident from her school days. However, women did not get university admission at that time, hence further education was not possible in Poland. In addition, the family's financial situation was difficult. Marie's elder sister, Bronislava wanted to study medicine. Marie and Bronislava then decided that, financially first Marie would help Bronislava for her education in Paris by working for two years, and then for the next two years, Bronislava would help Marie with her education. Accordingly Marie took a job of Governess (a teacher assigned to teach children privately at home in a wealthy family) at Zoravsky family. While working there, Marie fell in love with Kazimierz Zoravsky of the Zhoravsky family. Marie and Kazimierz both wanted to get married. But Kazimierz's parents did not give their consent to this marriage. After all, Marie was one of their poor servants. Kazimierz himself later became a renowned, professor of mathematics. Even after Marie's death, he used to get himself drowned in her memories!

In 1890, Marie's sister invited Marie to Paris for studies. Her sister, Bronislava, was now married to Kazimierz Dluski, a Polish doctor and they lived in Paris. At first, Marie refused to go to Paris because the university fees were too high for her. But Marie's father's financial situation had improved, and he decided to support Marie. Marie moved to Paris in 1891. There she temporarily stayed with her sister for a few days and then she found a room near the university and lived there. This room was an attic room under the roof of a house! In winter, poor Marie freezed in the cold! Besides, food was scarce as there was not much money in hand. The cold and hunger made her dizzy sometimes. But her strong desire to learn did not allow her to leave Paris under any circumstances. At the university she was studying physics, mathematics and chemistry. Her daily routine was to go to the university,

> **Marie Curie is of all celebrated beings, the only one whom fame has not corrupted.**
>
> – *Albert Einstein*

study in the afternoon and teach as a private tutor in the evening to earn money. In 1893 she graduated from the University of Paris. She then got a job in Professor Gabriel Lippmann's industrial laboratory. As a result, she was able to continue her university education. She received her second university degree in 1894. She then began research on different types of steels and their magnetic properties. At that time, she met Pierre Curie. Piezoelectricity and magnetic materials were the subjects of his research. As Pierre and Marie worked on similar subjects their acquaintance grew very fast. Young Pierre, was very good in his subject, and was already a scientist on the path to fame. He was working as an instructor in the School of Physics and Chemistry at the University of Paris. Joseph Viruz-Kowalski, a Polish professor in Paris, knew Marie and Pierre. Marie needed a little bigger laboratory for her research. Professor Kowalski requested Pierre to give Marie some space in his laboratory. Pierre agreed. Working together brought Marie and Pierre very close, and later Pierre put forth a marriage proposal. But she did not say yes because she loved her motherland! She wanted to go back to Poland and work there. Pierre even agreed to leave France and settle in Poland with her.

In the summer of 1894, Marie went to Poland alone. There she tried a lot to get a job. But in those times it was very difficult for a women to get a job. Poland's political situation also had not improved much. Pierre was sending her letter after the letter urging Marie to return to Paris and complete her Ph.D. work.

In March 1895, Pierre received his doctorate degree and was promoted as a full professor. Marie returned to Paris and got married to Pierre in July 1895. In him Marie found not only her husband but also a faithful friend and colleague. They worked together. Both of them enjoyed cycling or traveling abroad during the holidays.

X-rays were first discovered in 1895, and then in 1896, a scientist Becquerel discovered that X-ray-like, deep-penetrating rays were coming from uranium salts. The search began! Although the nature of this radiation was not known, it was an important discovery. Upon learning about this discovery, Marie thought of further working on these rays. She discussed the problem with Pierre, who was very impressed. They discussed it in depth. In order to study the unknown

rays emitted from uranium salts, it was important to know exactly how much (pure) uranium was in the substance taken for the analysis. It was decided to use an instrument known as electrometer to study the rays emitted from the salt. Pierre and his brother had built the first electrometer about 15 years ago. If the electrons of an atom and positive atoms (ions) due to loss of electrons were to get separated by ionization due to radiation, the negatively charged electrons and the positively charged atoms would be separated, then they should go to the positive and negatively charged electrodes (plates), respectively. This would create an electric current that could be seen by an electrometer. After using it, Marie noticed that the electric current depended on how many atoms of uranium were in the substance and the radiation emitted was the property of atoms.

Marie wondered if similar radiation was emitted from elements other than uranium. While chemically decomposing pitchblende the mineral found in the mines, Marie discovered that in addition to uranium, it also contained two other radioactive elements, polonium and radium, the names coined by Marie. They found that the intensity of the rays emitted by these atoms was much higher

Marie Curie with eminent contemporary scientists
Source: Solvay Institute

> **You cannot hope to build a better world without improving the individuals. To that end, each of us must work for our own improvement.**
>
> *– Marie Curie*

than that of the rays emitted from uranium. Both of these elements were new. No one knew them before! The name polonium was given by Marie to commemorate her native country, Poland. No matter where she worked, no matter she did not get a job in her own country, but her love for her motherland never waned!

Marie and Pierre immediately published their work. At that time, working on radioactive material was considered to be very top-notch problem. The race was unprecedented. Even though the release was delayed by 1-2 months, the honor of doing it first was going away! Marie, however, was working with Pierre's advice, and understanding the importance of this work. Pierre also focused on the work that Marie was doing. Marie had taken the lion's share in this work! She had written down minute details neatly in her work record. Marie and Pierre's work was published in April 1898. But their research paper on polonium was published in July 1898. Another research paper was published on radium in December 1898. In this work, they coined the term 'radioactivity' instead of 'uranium radiation' and used it. Later the same word became common in science! All of this was done in a garage space. Marie had to handle the huge equipment they needed to extract the radioactive material from the minerals found in the mines. It used to consume a lot of her energy. Moreover the harmful effects of radioactive substances were not known and Marie was working day and night handling the minerals without any protection. Without her realization Marie was slowly getting the effects of radiation on her body.

Between 1898 and 1902, Marie and Pierre published 32 research papers. In one of them, they showed that if the radium rays fall on the tumor cells and normal cells at the same time, the tumor cells would meet early death. Marie and Pierre began to become world famous due to their work on radioactivity.

Pierre joined the University of Paris in the faculty of science, and Marie also had the honor of being the first female faculty teacher there. Yet no one could believe that one woman did so much research! Marie's name was not mentioned in the 1903 Nobel Prize for Pierre and Becquerel. But one of the committee members was a woman, Magnus Gösta Mittag-Leffler. She felt that Marie was being treated unfairly. So she informed Pierre what was going on. Pierre then

made it clear to the Nobel Committee that he would not accept the Nobel Prize without Marie! The Nobel Committee then had to correct its mistake and finally they announced the 1903 Nobel Prize in Physics to Marie, Pierre Curie, and Becquerel.

> **Have no fear of perfection, you'll never reach it.**
>
> *– Marie Curie*

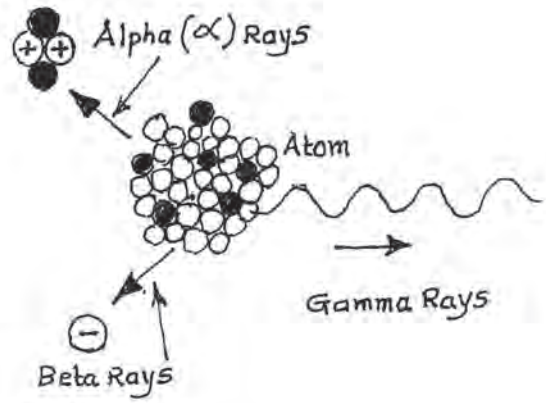
Perhaps it was because of the Nobel Prize that Pierre was invited as a professor at the University of Geneva. Seeing this, the University of Paris also made him a professor! Yet he did not have enough laboratory space, which was promised to him by the university. It was in late 1906 that he got it. Unfortunately in 1906, before that Pierre died in an accident as he was run over by a rash horse-drawn carriage. It was a big shock for Marie. They had two young daughters. Their youngest daughter Eva was only two years old and the eldest daughter Irene was ten years old.

After Pierre's death, Marie was given, his position by the university. However, the problem of inadequate laboratory space did not end! Knowing this scenario, the director of the Pasteur Institute invited her to come to their institution. He also proposed to set up 'Radium Institute'. When Marie threatened to quit the University of Paris, it finally woke up! It would have been definitely bad for the university that a reputed scientist like Marie Curie left the university! As a middle solution Marie started working both at the University of Paris and the Pasture Institute.

In 1910, Marie succeeded in separating radium from minerals. On one hand, she was proving her own existence as a scientist without her husband, while on the other hand she had to endure some public, personal and political criticisms. Even raising the young daughters without her husband was not an easy task. Despite the criticism she had to face, the Swedish Academy awarded her the 1911 Nobel Prize in Chemistry. Marie was and even so far is the only female scientist to win the Nobel Prize in two different disciplines. All her scientific work since her doctorate was carried out in Paris, France, still the French treated her as if she was a foreigner! She was never made a member of the French Academy of Sciences. However, in 1914, the French Government funded her to establish an independent Paris Radium Institute.

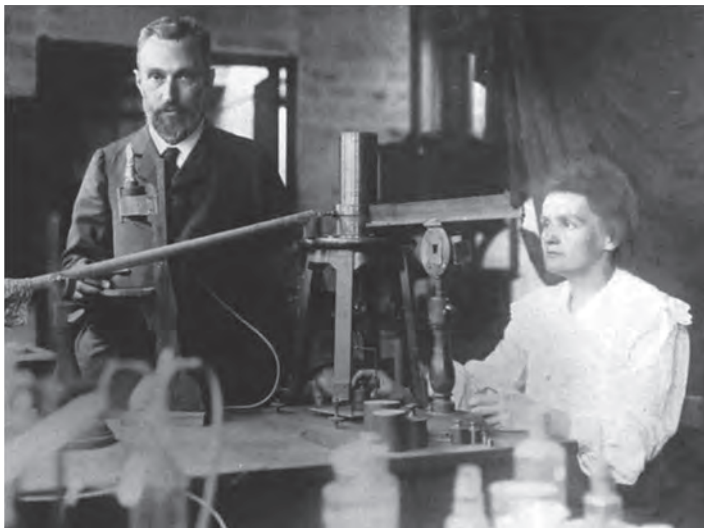
With the outbreak of World War I, many scientists went on war duty. Until 1919 all the research work had stopped. Even though many in France treated her badly, Marie was compassionate and forgiving. She had taken French citizenship. She considered both Poland and France to be her own, and felt it was her duty to

work for the people there. As the war had progressed, Marie quickly learned radiology, the human body, motor vehicle mechanics and developed X-ray machines that would be useful to surgeons on the battlefield. She became the chief director of the Red Cross Radiology Service.



After the war, she traveled to many parts of the world to raise funds for the Paris Radium Institute. She was warmly welcomed everywhere. French government decided to give her 'Legion of Honor' the highest award in France, but she refused to take it. Marie's health was deteriorating day by day. She used X-rays as well as many radioactive substances without any care and she developed visual impairment. She died on July 4, 1934, at the age of 66, of aplastic anemia. She was laid down in the tomb next to Pierre's tomb in the Passi, Haute-Savoie in France.

In 1995, bodies of Marie and Pierre Curie were moved to the Pantheon, Paris. Here in Pantheon are preserved remains of some highly respected French citizens. Marie was the first female to be buried there. Poland has two museums named after Marie Curie. Her statues can be seen in many places. The postage stamps with her photo are released. In many countries and languages, books have been written on Marie. She is also mentioned worldwide in the textbooks for school children. There is no doubt that the patriotic, hard working and compassionate Marie Curie, who devoted herself to science in odd situations, will continue to be a role model for young boys and girls.



Marie and Pierre Curie in their laboratory

Lise Meitner

THE NOBEL PRIZE MISSED DUE TO RACISM ...

(1878 – 1968)

Albert Einstein affectionately referred to her as 'Our Madame Curie'. Lise Meitner was a Jewish woman who worked in nuclear physics, combating both racism and sexism. Working on a frontline and difficult subject like disintegration of the nucleus she was the first to find out the reasons behind nuclear fission, but all the credit for the Nobel Prize for it was taken by her colleague, taking advantage of the bad situation at that time. But after the end of World War II, facts slowly came to light and she gained the sympathy of the scientists and got other honors of scientists! But unfortunately, the highest Prize (Nobel) was missed.

CHAPTER FIFTEEN

Lise Meitner at work, around 1930

Credit:
https://www.dpma.de/english/our_office/publications/ingeniouswomen/lisemeitner/index.html

Lise Meitner was born on November 7, 1878, in Vienna, the capital city of Austria in Europe. Her name was actually 'Elisa' but later she started using 'Lise' as her name. Her father, Philip, and mother, Hedwig Meitner, were Jewish by birth, but they did not attend or participate in any religious ceremonies. Lise was the third of their eight children. Lise's father was a lawyer and their domestic environment was modern and conducive to education. From her childhood, Lise Meitner liked mathematics and science. From the age of 8, she wrote down some of her observations in a notebook and kept it under her pillow. In those days, in Austria, girls were not allowed to continue their education after the age of 14. So at the age of 14, in 1892, Lise had to leave the Public School of Girls where she was studying and stay at home. She learned French and got a job at a school. Fortunately, in 1897, within a few years of leaving her school, universities opened up for women in Austria. As few years had elapsed while she left the school, she took up private tuitions to gear up and enrolled in university in 1901. Ludwig Boltzmann who has played a key role in laying the foundations for the 'statistical mechanics' was one of her physics teachers. Statistical mechanics is very useful in physics, for understanding the properties of atoms and solids. Even today Boltzmann's contribution is considered to be great. He was not only a great researcher but also a great teacher and philosopher. He used to say, "Physics leads to the ultimate truth." This philosophy had a profound effect on Lise's mind, and she began to feel that life was empty, meaningless, without physics.

Lise received Ph. D degree in 1906 under the guidance of Prof. Franz S. Axner. Her work was on the transfer of heat in matter. Even after Ph.D. it was difficult for women to get a job then, better than a school teacher and Lise wanted to do more research in physics!

At that time, Germany was known as the center of physics. Famous scientists who made great discoveries were engaged in research in Germany. So Lise took the road straight to Berlin (Germany) never to return to Vienna! Her father not only helped her financially but also encouraged her to become a researcher. At first she saw the possibility of working with Marie Curie. Marie Curie's work on radioactivity was very famous at that time. She had also won the Nobel Prize. Therefore, Marie Curie was the role model for young girls. But Marie Curie refused and Lise tried to work with Max Planck. Max Planck was not very keen on women's higher education. But, seeing that a woman has left her home only for research, he thought that her perseverance would be good and he allowed Lise to work with him. At that time Max Planck was at Friedrich-Wilhelms University in Berlin.

> **Science makes people reach selflessly for truth and objectivity; it teaches people to accept reality, with wonder and admiration, not to mention the deep awe and joy that the natural order of things brings to the true scientist.**
>
> *– Lise Meitner*

There she began researching with Max Planck.

Max Planck was awarded the 1918 Nobel Prize in Physics. His research laid the foundations of quantum mechanics. There are now many Max Planck Institutes in Germany named after him. So the opportunity that Lise got was no less than working with Marie Curie. Although Max Planck was initially reluctant to take her, later he began to respect Lise for her work and intelligence. He began to help her as much as he could. Max Planck even allowed her to attend his lectures. It was a wonderful opportunity for Lise. Max Planck's method of teaching was also of a very high standard. Around the same time, she met Otto Hahn. Otto Hahn was a radiochemist. The two decided to combine his chemistry and her physics knowledge to work on radioactivity.

Between 1907 and 1912 Lise published 20 research papers with Hahn. Lise rose in prominence as an intelligent scientist of the time. Her nature was a bit shy. But she had a lot of friends because she loved music and wandering in the wilderness. She also attended the weekly scientific meetings in Berlin. About 30-40 leading scientists, including Nobel laureates Albert Einstein, Max Planck, Niels Bohr and James Frank attended the meeting. Lise was honored to sit next to them. Einstein used to call her 'Our Madame Curie'. There were definitely some similarities between Lise and Marie Curie's life. Both were women, research enthusiasts, and were doing research in a different country than their home country. The research of both was also on radioactivity. Both of them were hard working and became famous. Both were intelligent. But Lise was not as lucky as Marie Curie! Lise had no financial support for the research. She had to live on the money her father sent her. In 1912, however, the picture changed. Nearby Berlin is a small village called Dalhem. The Kaiser Wilhelm Institute for Chemistry was established there. There, Max Planck appointed Hahn as Professor and Head of the Department of Radioactivity. Lise, however, was appointed as 'guest assistant scientist'. Of course they could only do so much for her. But now she was getting paid for research. In 1913, Lise took the first step in the field of German academic profession.

All had started going on well for Lise, but then World War I broke out. Lise and Hahn could not do research work. With Germany taking an active part in the war, Hahn was out in the latter part of the war, and Lise had to run the laboratory alone. In 1916, Lise was given a small physics department. She succeeded in finding and isolating an atom called protactinium. It is number 91st element in the periodic table. There was no definite proof as to which atom could be between Thorium (Atom No. 90) and Uranium (Atom No. 92). The atomic number does not depend on the weight of the atom but on its electric charge. Besides, the atomic number can change when radiation is emitted from the nucleus. A very short-lived (half-life of 6.7 hours) atom, called Brevium was discovered by two other scientists Kazimierz Fajans and Oswald Helmuth Göhring in 1913. Thorium gets converted from uranium to protactinium by radioactive process. The name was Breivium (short-lived). But Otto Hahn and Lise Meitner discovered a very long-lived (half-life 32,000 years) atomic number 91 atom. They named it 'Proto-actinium'. It was an isotope. There can be two or more atoms of the same atomic number but of different weights. They are called isotopes. Lise and Hahn's research on the existence of atom number 91 left no doubt, and this atom came to be renamed as protactinium (pro means 'before'). This research is known in the name of Hahn and Lise.

After this work, however, the two began to focus on slightly separate research. Lise turned her attention to nuclear physics and Hahn continued to work in radiochemistry. During that time, Lise's research on radiation emanating from the nucleus using a magnetic spectrometer made her one of the world's best scientists. She had planned to study all the aspects of the nucleus. It was the golden age of nuclear research. The subject was constantly evolving. Lise also did research on cosmic radiation, artificial changes of

Meitner received the Enrico Fermi Award in 1966. Her nephew Otto Frisch is on the left. (Credit: IAEA, CC BY-SA)

> **I think young people reflect on how they would like their lives to unfold, and when I did, I always came to the conclusion that life doesn't have to be easy as long as it isn't empty.**
>
> – *Lise Meitner*

nuclei and scattering of nuclei. It was during this time that in 1923, she saw the radiationless transitions of atoms. But she did not pursue it further. Pierre Auger, a French scientist studied this effect in more details in 1925 and it is now known as the Auger-Meitner effect.

In 1925, Lise was awarded the Liben Prize. In 1926, she was also appointed as a professor at the University of Berlin. She was one of the first few women to become a professor in Germany. Shortly thereafter, she and her fellow scientist, Kurt Philip, managed to observe electrons–positrons from a non-cosmic source of radiation. In 1932, Chadwick discovered the neutrons with no electric charge, existing along with protons (positively charged) in the nucleus. Enrico Fermi, a well-known scientist in Rome, Italy, in 1934 began to study the possibility if uranium could be converted into atoms heavier than uranium by striking neutrons. Lise was also inspired by these experiments and started working on it in Berlin as well. Unfortunately, the political situation in Germany was very tense. Hitler first imposed many restrictions on people of Jewish descent and then began to exterminate them. Many of her colleagues and friends advised her to leave Germany. But she did not want to give up her ongoing research. By 1938, however, the situation was so bad that it was impossible for people of Jewish descent even to leave Germany. In fact, Lise had voluntarily become a protestant in 1908, but because Hitler's opposition was more racist than religious, Lise's life was also in great danger.

Finally, in 1938, with just two bags in her hands, Lise, with the help of some friends, first escaped to Netherlands and then to Stockholm, Sweden. There she began research at the Nobel Institute for Physics. But she was not satisfied there. Her home and institute were far away. Besides, she didn't get much support from her co-workers. Her work on possible formation of an artificial atom that weighs more than uranium, by striking neutrons on uranium, was continued by Otto Hahn while she had to remain in Sweden. She used to regularly send letters to Hahn almost every day of the week. Hahn, however, was not regularly corresponding with her. He did not want to provoke the wrath of Hitler or the

Nazi party by corresponding with a Jewish woman. But secretly he was seeking the interpretations of the experiments, as adequate theoretical knowledge was required along with the actual experiment. He was a chemist and Lise was a physicist. In these experiments, knowledge of physics was more important than chemistry. However, they did not get the expected success in this experiment. The uranium atom was expected to form a heavier atom by absorbing neutrons (because neutrons were expected to weigh almost as much as protons), but while she was experimenting in Berlin and later Hahn and Strassman continued to bombard uranium atoms with neutrons, they observed the resulting atoms with smaller weight than uranium.This was not clear to Hahn, Strassman or Lise. The experiments were actually going on well! Lise was thinking about this day and night. One day, she and her nephew, Otto Robert Frisch, who himself was working in physics, went hiking. Along the way they were discussing this experiment. Then they thought that as if a large drop of water from a tap, splits into smaller droplets same way uranium, if bombarded with lighter particles than it, would split into smaller pieces. Lise immediately wrote this idea to Hahn but Hahn refrained from answering her. Instead he immediately published the results with explanation given by Lise under his and Strassman's name, with of course Lise's explanation! When the Nobel Prize in Physics for Nuclear Fission was announced in 1944, Lise's name was omitted! In this way, Lise was deceived. Lise and Robert Frisch also wrote a research paper detailing with the theoretical explanation of nuclear fission, the energy generated during fission, but it was only after Hahn's publication and always 'first published' work is considered for the Nobel Prize. Besides a powerful scientist from Sweden is said to have tried to get rid of her name from being considered for the Nobel Prize! For the most part, she was projected as an 'assistant' at work in Germany. The truth came out sometime later when Strassman mentioned Hahn and Lise's correspondence and historians also discovered it. By then it was too late!

At the end of World War II, Lise was invited to become the director of the Max Planck Institute in Mainz, Germany, but she turned down the invitation. She did not want to go back to Germany because of the bitter experience of

her German colleagues during the critical time. She was invited in 1943 in Los Alamos, USA. But she did not wish to work on nuclear weapons. So she did not go there either. The enormous energy generated in nuclear fission causes huge destruction. She did not like the fact that the atomic bomb had the same principle as that of her work and was used to make weapons in this way.

In 1949 she was awarded the Max Planck Prize. Interestingly, in 1955, she was awarded the Otto Hahn Award! Lise didn't like the way she was treated by the Germans but neither did Lise hate Hahn even after his relinquishing her out of the Nobel Prize. Their relationship remained friendly. The Otto Hahn award was a compensation for the injustice done to her. She became a Fellow of the Royal Society of England in 1955. In 1960, she received the Wilhelm Exner Prize. She helped build the first nuclear reactor in Sweden. She also worked for various organizations in Sweden. Since she had many relatives there, in 1960 Lise moved to England. She received the Enrico Fermi Award in 1965 but due to her illness, she could not go to America to receive it. Lise was awarded honorary doctorates by 5 universities and many academies gave her membership. The city of Vienna also awarded the Science Prize to Lise. Thus she received many prestigious awards from various places.

Lise Meitner died in sleep in England on October 27, 1968. An organization working on a nuclear power plant in Berlin, Germany, was later renamed as the Hahn-Meitner Institute. In Germany, Austria, Sweden and England many schools and roads are named after her. The craters on the Moon and Venus have been named after Meitner. In 2008, the Austrian Army instituted an award in her name. In 2010 a building at the Free University in Berlin was named after her. The building was formerly known as the Otto Hahn Building. Her statue was erected in 2014 at Humboldt University of Berlin. In 2015, the University of Alba Nova in Stockholm, Sweden began an annual Lise Meitner Lecture. Similarly, the artificial atom having atomic number 109 has been given the name 'Meitnerium' and her name has thus been immortalized.

Meitner's tombstone on which is engraved 'A physicist who never lost her humility'

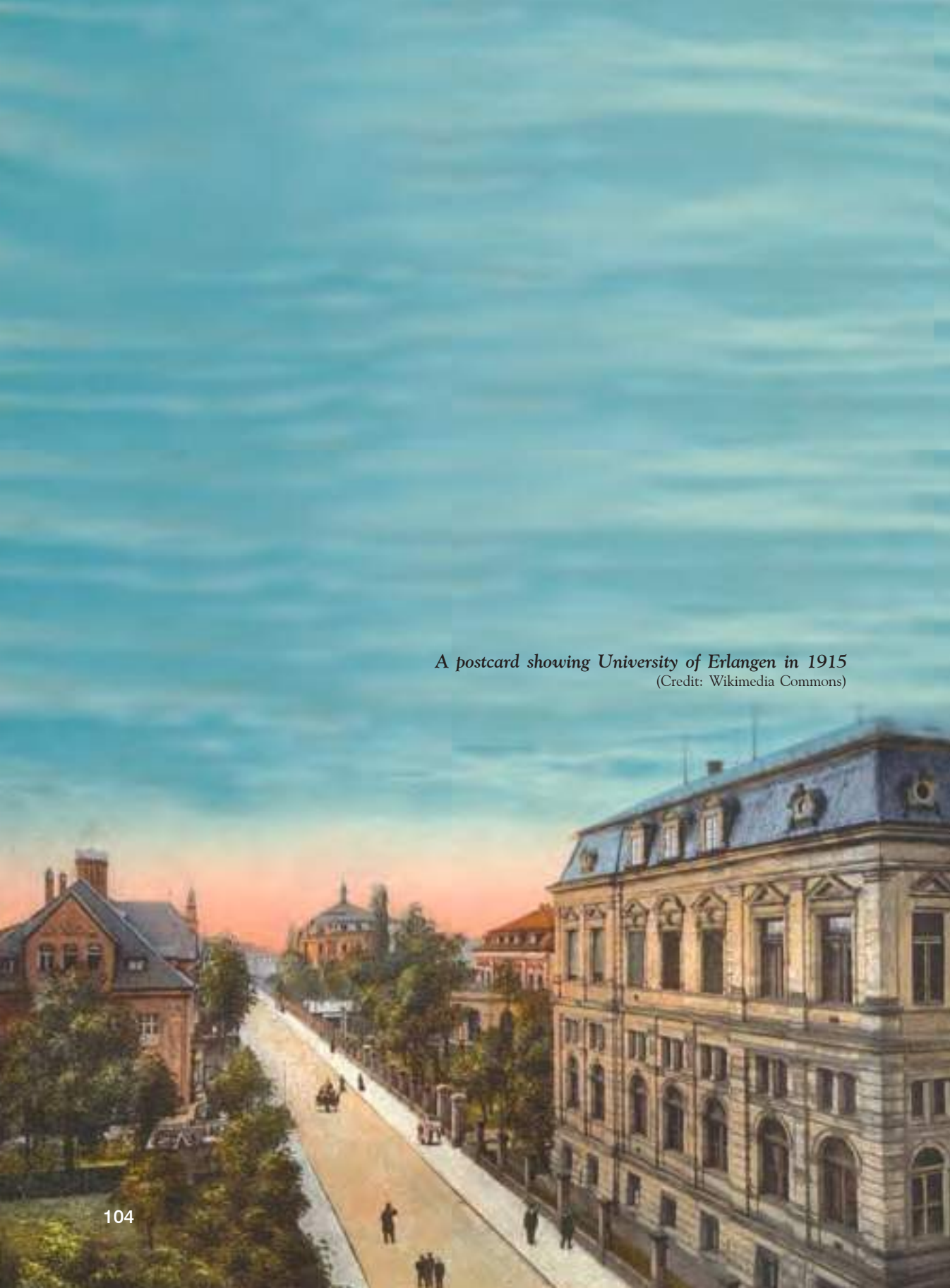
Emmy Noether

EXCEPTIONAL MATHEMATICIAN...

(1882 – 1935)

Amalie Emmy Noether started studying mathematics at home with the encouragement of her father – a professor of mathematics, at the time when women in Germany did not have entry to university. Despite strong support from her family her education and career path were tough. With her original thinking and perseverance she focused on algebra and theoretical physics and soon became very famous. Great mathematicians and scientists like Albert Einstein, David Hilbert, Powell Alexandrov, Herman Weil, Norbert Weiner and many others have described her as the most important scientist in the history of mathematics.

CHAPTER SIXTEEN



A postcard showing University of Erlangen in 1915
(Credit: Wikimedia Commons)

Amalie Emmy Noether was born on March 23, 1882, in Erlangen, Bavaria, Germany, to a German Jewish family. Amalie Emmy was the eldest of Ida Amali and Max Noether's four children. She had three younger brothers. When Emmy grew up, she dropped 'Amalie' from her name and continued as 'Emmy Noether' and is known by the same name. With an educational environment at home and a good mathematician father, Emmy naturally became interested in mathematics. Her father had a doctorate in mathematics from the University of Heidelberg, and he taught mathematics at Erlangen. He was well versed in 'Algebraic Geometry'. He had contributed well in this subject. In simple language and in short, solving equations of different curves (for example, straight lines, circles, ellipse, etc. in 1, 2 or 3 dimensions) is called algebraic geometry. It was an advanced subject of mathematical research in the 19th century.

Emmy was known as a smart student at school. She was good at solving quizzes and puzzles. She had to learn how to cook and clean the house according to the tradition of that time. All the girls were supposed to learn it. Emmy was also good at piano although she didn't like it very much. Emmy however loved to dance. After completing the school education, Emmy wanted to teach French and English in school and passed the required examinations. But then she became more interested in mathematics and decided to study at Erlangen University, where her father taught. There she was allowed to sit in the classroom with the permission of the professors but she was not allowed to take any examinations, as women were not allowed in the university! In 1903 she graduated from Nurenberg. In 1903-04, she had the opportunity to listen to lectures delivered by renowned mathematicians such as Hermann Minkowski, Otto Blumenthal, Felix Klein, David Hilbert and scientists such as Carl Schwarzschild at the University of Göttingen. In the late 18th and early 19th centuries, the University of Göttingen was famous for its scholarly research. When Emmy started going there, women did not have official admission to the university. She was only allowed to listen to lectures. The rules changed soon after a while and the doors of universities were opened for higher education to women in Germany.

On October 24, 1904, Emmy Noether was officially admitted to the University of Erlangen. She presented her dissertation in just three years under the supervision of Paul Gordon and received the doctorate from the university. However, women were not allowed to teach at the university. Permission to learn but not to teach! Therefore, from 1908 to 1915, for seven years she taught unpaid at the University of Erlangen. Sometimes she taught in place of her father and sometimes in the place of some sick professor. She also published some papers in 1910-11 based

on some parts of her Ph.D. thesis. Thus, her work was never interrupted. Her financial responsibilities were taken care of by her father and brothers. They encouraged her to work. Her work also was slowly gaining appreciation.

Impressed by her work, Emmy was invited to Göttingen in 1915 by David Hilbert and Felix Kline. It was a great honor for Emmy. She even went to the University of Göttingen. Hilbert, Kline, and a few other professors worked hard to get her a job there. But some protesting professors began to say, 'When your soldiers come back from the war, how can they sit at a woman's feet and learn?'Prof. Hilbert replied 'The university is a place of learning, not a public bathroom where discrimination should be made on the basis of gender.' But the university law of the time did not give a job to Emmy. However, Emmy continued to work as Prof. Hilbert's assistant taking some of his lectures and doing research. At the same time, she developed a theorem known as 'Noether Theorem', which is very famous and useful in physics. The Noether Theorem has become very important for the development of modern physics. Noether's important work was on 'Invariant Elements'. In physics it is considered very important. Albert Einstein himself encountered mathematical difficulties in some of the questions in his theory of relativity. He asked Prof. Hilbert and Prof. Kline for some help. They confidently placed that responsibility on Emmy Noether. Emmy's work helped Einstein solve his problems. Einstein was very impressed by her intellect.

After the First World War in 1918-19, there were significant changes in the thoughts of the German society. In 1919, after the necessary period to become a professor in the university after Ph.D. was over she also gave the mandatory lecture. Three years later, Emmy was appointed as extraordinary professor. The 'regular or ordinary professor' was the highest professor position in the university and Emmy got the 'extraordinary professor' position, which was the lowest position! So her colleagues would jokingly say, 'the extraordinary professor does not know anything ordinary, and ordinary professors do not know anything extraordinary. Her colleagues were aware of her knowledge and abilities. They used to feel bad that she was not being given the place and salary she deserved.

However, the scholar Emmy was always immersed in her world of mathematics. She had her own group of students. She used to be so engrossed in teaching and research that she used to be unaware of the latest costumes or hairstyles around her. She wore a long, loose robe and went around in it anywhere. Even if the hair became ruffled while teaching or the chalk powder fell on the blouse or skirt and made it look strange, she used to be still engaged in her own thoughts and did not care much. When there was no fashion of women cutting hair, she cut her hair

up to the neck. While teaching, she could easily find some new mathematical methods on the board. She enjoyed the company of students very much. If there was a holiday, she would teach or discuss with the students sitting in the garden or on the steps of the building. She also used to discuss her ideas with her colleagues. She never liked to keep her thoughts and ideas as secrets but discussed them openly. She encouraged her students to develop their own ideas. The innate qualities of a good teacher were abundant in her. The students in Emmy's group were jokingly called 'Emmy's children'.

> **...it is surely not much of an exaggeration to call her the mother of modern algebra.**
>
> *– Irving Kaplansky*

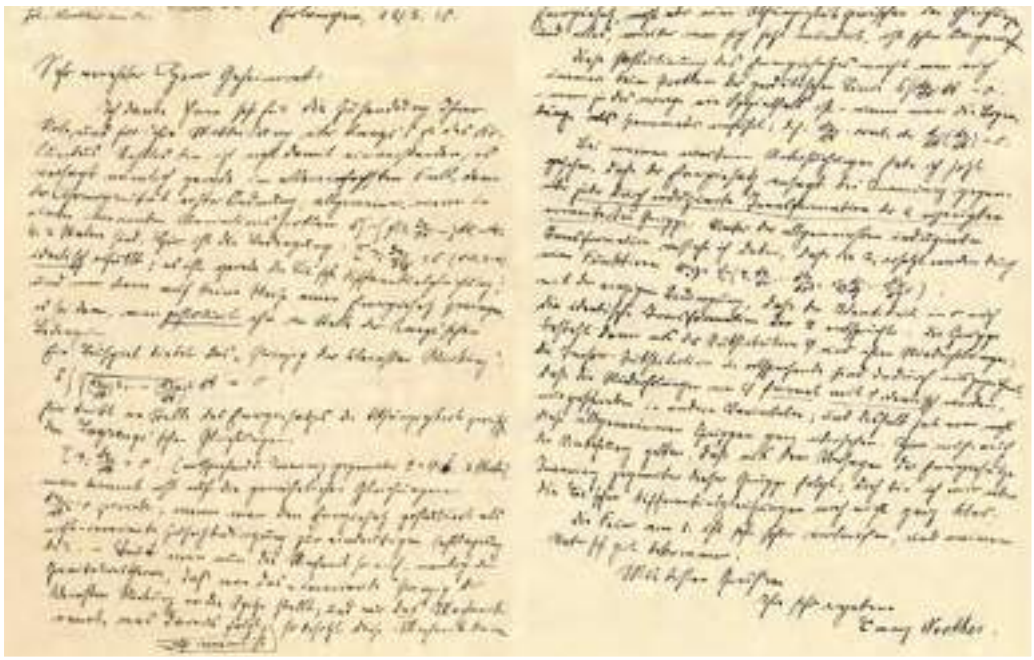
Emmy used to be a special guest at many important mathematics conferences in the country and abroad. Invitations used to pour. She also gave some lectures for a few months on invitation in Moscow. In 1932, she shared with Emil Artin the 'Ackermann –Taubner' memorial award. But her colleagues always felt that she should have received the honorary membership of the Göttingen Academy of Sciences. She didn't get it until 1933.

In 1933, the atmosphere in Germany suddenly changed. Adolf Hitler became the head of Germany. Jews were either imprisoned or killed. Emmy Noether, being a Jew, had no choice but to leave the country immediately. She got a temporary teaching appointment at Brin Moore in the USA. Later, in 1934, Abraham Flexner and Oswald Veblen of Princeton University invited her there and her work resumed. But there she felt it was just a men's university! Still due to some good colleagues and work Emmy was happy. But in April 1935, she fell ill. She was diagnosed with cervical cancer and underwent surgery. Unfortunately, she died on April 14, 1935, at the age of 53. After her death, Albert Einstein wrote a condolence letter in the New York Times. In it, he mentions Noether as a high-ranking scientist. He wrote that Emmy Noether was the most creative and genius female scientist after the women's education had started.

Emmy Noether's work dates back to a time when theoretical physics and mathematics were not considered separate. The scope of her work was very large. According to one of her fellow scientists, Emmy's work was to create a new way of thinking in mathematics. Her work can be mainly divided into three periods. From 1908 to 1919, she worked in the field of theoretical algebra, algebraic invariants and number fields. The well-known 'Noether theorem' is related to the conservation law and is crucial for the advancement of modern physics.

> **E. Noether's famous 1918 paper, "Invariant Variational Problems" crystallised essential mathematical relationships among symmetries, conservation laws, and identities for the variational or 'action' principles of physics… Thus, Noether's abstract analysis continues to be relevant to contemporaray physics, as well as to applied mathematics.**
>
> *– Gregg Zuckerman*

From 1920 to 1926, her work was considered to have changed the face of algebra. The theory behind the 'ring domain' and the 'Theory of Ideals in commutative rings' are used in many places as a good tool. Substances that meet the ascending chain conditions are called 'Noetherian' in her honor. Emmy's third period of work was from 1927 to 1935. During that time she did admirable work on non-commutative algebra and hyper-complex numbers, as well as on the theory of representation



March 12, 1918, a letter to Felix Klein, professor of mathematics in Göttingen on the topic of her research. (Credit: Eldestein Collection at the National Library of Israel)

of groups. All her work in mathematics and physics was admirable and a great guide.

> **My methods are really methods of working and thinking; this is why they have crept in everywhere anonymously.**
>
> – *Emmy Noether*

Her work has been remembered by naming some schools (including her school in Erlangen) after her and in various other ways. The Association for Women in Mathematics organizes a 'Noether Lecture' every year. Founded in 1971, it is headquartered in Fairfax, Virginia, USA. It has about 5000 members. The campus of the University of Siegen in Germany, where departments of mathematics and physics are located is called the Emmy Noether Campus. One of the programs of the German Research Foundation is called 'Emmy Noether Program' which encourages young scientists to form their groups of research. The street where the Noether family had a

Emmy attended her lectures in the then still relatively new Kollegen Haus, built in 1889

Einstein wrote a beautiful obituary about her in the New York Times:

> **In the judgment of the most competent living mathematicians, Fräulein Noether was the most significant creative mathematical genius thus far produced since the higher education of women began. In the realm of algebra, in which the most gifted mathematicians have been busy for centuries, she discovered methods which have proved of enormous importance in the development of the present-day younger generation of mathematicians. Pure mathematics is, in its way, the poetry of logical ideas.**
>
> *–Albert Einstein, New York Times, May 1, 1935*

house in Erlangen is named after them. Since 2001, every summer Göttingen University organizes a competition for the school children in honor of Emmy Noether. The Institute for Theoretical Physics, Waterloo, Ontario, Canada offers an annual Emmy Noether Visiting Fellowship. It is also the main venue of the Emmy Noether Council. Council Members try to increase the participation of women in mathematics and physics. In collaboration with Israel-Germany Emmy Noether Mathematical Institute has been established in Bar-Ilan University, Ramat Gan, Israel. The main character in Ransom Stephens' fictional 'Emmy Nutter' is based on Emmy Noether. A crater on the moon has been named 'Noether' in her honor. The asteroid 7001 is named after Emmy Noether. On 23rd March 2015, Google celebrated her 133rd birthday by posting a doodle on its homepage. Thus, even though a handful of scientists at her time denied the recognition due to her, merit of Emmy Noether's work is hailed in the world even today.

Inge Lehmann

INSIDE THE EARTH...

(1888 – 1993)

Women's education began in some parts of Europe in the late 19th century. Born, educated and raised in Denmark, Inge Lehmann is one such female scientist who could get education without hurdles. She proved that the center of the earth, as big as the moon, is solid, and not liquid. This is now universally accepted. This theory differed from earlier opinions about the interior of the earth. Scientists earlier believed that central volume of the earth, enveloped by rocks and other solid matter contained liquid. It is very interesting that in a country where earthquakes do not occur, Inge Lehmann had made such an important discovery.

CHAPTER SEVENTEEN

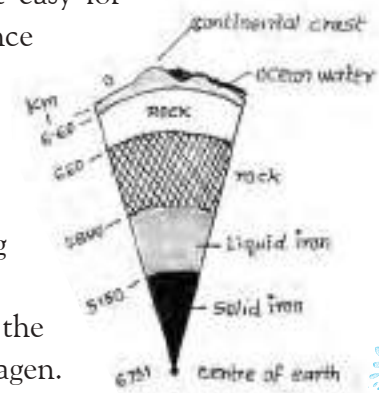
Inge Lehmann sits on the far right as the only female seismologist in the scientific society

By the end of the 19th and beginning of the 20th century the importance of women's education was well understood in the European society and girls began to receive the same standard of education as boys. This must have been the sequel of World War I. Born in Copenhagen; the capital city of Denmark in Europe, Inge Lehmann is an august example of how women have come to the fore in modern European society and in the way the society has evolved.

Inge Lehmann was born on May 13, 1888. Her mother was a housewife and her father a psychiatrist. In Copenhagen there was a high school run by the aunt of the well-known scientist Niels Bohr (the scientist famous for his basic research on the structure of atom). It was a school known for its very progressive teaching. The school had co-education. It was indirectly emphasized that girls are not inferior to boys or there had to be no discrimination between men and women. The boys and girls in her school were getting the same treatment. Inge's education in this school was great. But later on, she has said that according to her own experience, often in the outside world equality is rare! Unfortunately, at work, worldwide many women experience gender discrimination. At the same time, she further said, 'the bad thing is that the women who are very efficient often have to compete with incompetent men'.

In 1907 after passing the school with first rank, Inge entered Copenhagen College. There she began studying mathematics, physics, and chemistry. But after getting the admission at Newnham College in the University of Cambridge in 1910 she went to England to study mathematics. Within a year, her health deteriorated, and she had to return back to Denmark in 1911. After taking some rest she worked for an insurance company for some time. In 1918 she again took admission in the University of Copenhagen. In 1920, Inge graduated with a degree in mathematics.

At the beginning of the 20th century, it was not easy for a woman to establish herself as a pioneer in science by working alone in a different field. Inge liked intellectually stimulating discussions. She could not bear to have nonsense discussions or could not stand people who would spend time in gossip! Inge had a lot of physical ability and enthusiasm. She loved hiking in the Alps and Norway.



After graduation, she got a job as an assistant in the insurance department at the University of Copenhagen.

In this job she had to study insurance. But, she soon joined the seismology department. She learned from Prof. Niels Norlund how to analyze information about the earth's crust and earthquakes. In 1925, Prof. Norlund assigned her the job of installing 'seismograms' in various villages in Denmark. Due to the First World War, there was a lack of funding for the work. Sheer passion and perseverance towards work was required during such a time moving around in such a situation. She had to walk a lot for work, not only due to shortage of funds but also because of the risk of moving around in such a situation. Inge got three young assistants for this work. Interestingly, none of them had ever seen an earthquake measuring device before. It was also strange to work on earthquakes in a country where earthquakes never occurred. It was Inge's responsibility to prepare them for this work!

While doing the daily work, Inge began to study seismology without any help. In 1927, she went abroad for three months. For a month she worked with Prof. Beno Gutenberg at Darmstadt in Germany. She found it helpful to interact with an experienced man like him. In 1928, while still working, she received a Master's degree from the University of Copenhagen. Prof. Norlund immediately

Inge Lehmann's Cottage

appointed Inge as head of the seismology department at the newly started Royal Danish Geodesic Institute. She worked there till her retirement in 1953. There she had the important task of keeping all the machinery in order. It was not compulsory for her to do research but was free to do it if she wished. There she sometimes had assistants. But since she liked research, it was a good opportunity for her to study seismology.

> **"I may have been 15 or 16 years old when, on a Sunday morning, I was sitting at home together with my mother and sister, and the floor began to move under us. The hanging lamp swayed. It was very strange. My father came into the room. "It was an earthquake," he said. The center had evidently been at a considerable distance, for the movements felt slow and not shaky. In spite of a great deal of effort, an accurate epicenter was never found. This was my only experience with an earthquake until I became a seismologist 20 years later."**
>
> *– Inge Lehmann*

The 'seismogram', an instrument used to measure earthquakes in any part of the world, was developed during the 1920's. Wherever there is an earthquake anywhere in the world, its waves spread through earth, all over the world. Their intensity varies with the distance from the source. But their speed depends only on the density through which the waves pass. They are accurately recorded in seismic observatories around the world. It was Inge Lehman who studied seismic waves and asserted their existence. Earlier it was assumed that lava extended up to the center. Surprisingly it was seen that the seismic waves were recorded even where the seismic waves could not reach! However, as Inge Lehmann found out, if there is a mass of solid matter in the center of the earth, then there is no discrepancy in any

Seismic station with Inge Lehmann, 1928
(Credit: Inge Lehmann's archive, Danish National Archives)

Newnham College entrance gate-(Inge Lehmann Collection, The Danish National Archives)

of the records and analysis. Therefore, the previously mentioned classification of the four shells (further shells are drawn in detailed studies) of the earth has now become accepted. In this way, Inge Lehmann added great value to the knowledge of the earth.

Even after retiring in 1953, Inge's passion for work continued. Her relations with scientists at home and abroad remained unbroken till the end.

Inge Lehmann received numerous awards for her work since 1938. Some of these awards are, Tagea Brand Rezselegat in 1938, Gordon Wood Award in 1960 and Emyl Wichert Award in 1964. Inge was awarded honorary doctorate by the University of Copenhagen and Columbia University 1968 and 1971, respectively.

Inge Lehman, who has always been happy, had a long life! Inge Lehman died in Copenhagen on February 21, 1993, at the age of 104. In 1995 the American Geophysical Society decided to award a medal in the name of Inge Lehmann, which began in 1997, to a scientist who has done outstanding research on the structure, components, or motion of the Earth's interior. The asteroid 5652 was named Inge Lehmann in 2015. On her 127th birthday, Google launched a doodle. In the year 2017 a monument was erected at Frue Plads, Copenhagen in honour of Inge Lehmann.

Janaki Ammal Edavalath Kakkat

SUGAR QUEEN OF INDIA...

(1897 – 1984)

Most of the women are generally fond of flowers and gardening. But hardly any Indian woman of the early twentieth century is known to have chosen to do research on variety of Indian and European plants. Janaki Ammal made exceptional contribution to botany. Besides her magnificent work on sugarcane and magnolia her work on medicinal plants, garden plants as well as tribal plants is famous. Janaki Ammal is known as 'sugar queen' and a variety of magnolia with small flowers is named as ' Janaki Ammal' which is sufficient to tell the importance of some of her work.

CHAPTER EIGHTEEN

Sugarcane Breeding Institute, Coimbatore

Janaki Ammal Edavalath Kakkat or Janaki Ammal for short was born on November 4, 1897 in the town Tellichery (now Thalassery) in Kerala. Her father, Edavalath Kakkat was a sub-judge in the Madras (now Chennai) Presidency. Her mother Devi Kuruvai was an Anglo-Indian. Janaki's grandmother was Indian and her grandfather was British. Janaki had five sisters and six brothers. They were Thiyya which was considered to be one of the lowest castes in the society. Besides, it was a male dominated society and girls were not encouraged to get education. However, Janaki's parents encouraged their sons and daughters to take proper education.

Janaki's father was interested in natural science and gardening. This had been instilled in Janaki since her childhood. She too liked plants of all kinds. Kerala, where she spent her childhood is world famous for its spices and natural heavenliness. This must have influenced her journey towards botany. She completed her school education from Sacred Heart Convent in Thalassery. For Bachelor's Degree in Science (B.Sc.) Janaki attended Queen Mary's College and got an Honours degree in Botany (1921) from Presidency College both in Madras. Probably observing her inclination towards Botany her teachers also encouraged her to pursue research in Botany.

Janaki taught in Women's Christian College Madras for two years but realized that her heart was in research and not just teaching or even getting married. Therefore, as soon as she was offered Barbour scholarship she went to the Michigan University in 1924. She obtained Master's Degree (M.Sc.) in Botany (1926). Janaki came back to Women's Christian College, Madras but soon returned to the Michigan University as she received Oriental Barbour fellowship for research in Botany. Janaki submitted her thesis on chromosome studies on a flowering plant *Nicandra physaloides* (also known as 'apple-of Peru' or 'Shoo-fly plant'). In 1931 Janaki obtained D.Sc. from the Michigan University. Her work in Michigan and later scientific work in Botany was appreciated by the Michigan University again in 1956, by conferring her an honorary LL.D.

From 1932 to 1934 Janaki taught in Maharaja's College of Science in Trivandrum. But there were not enough facilities or appreciation of research at the college level. So she decided to remain in teaching until good research opportunity came along. In 1934, Janaki got a research scientist's position at Sugarcane Breeding Institute (SBI), Coimbatore. Here the goal of the institute was to achieve high sugarcane yield and new varieties using hybridization techniques. This was precisely what Janaki would have liked and was Janaki's field of specialization in cytobiology. Janaki developed many sugarcane varieties of increased sweetness

and yield by hybridization. She can therefore be called as 'sugar queen' due to whom sweetness of sugar increased! However, she was enduring hardships at work place. In those days agriculture as well as research were male dominated fields and Janaki was a lonely female scientist. Her brilliant work also would have been the point of jealousy among her troublesome colleagues. Janaki became the fellow of Indian Academy of Sciences in 1935.

In 1939, Janaki got an opportunity to attend the International Congress of Genetics in U.K. Although she had initially not planned for it, due to the outbreak of World War II, she could not immediately return back to India. Janaki got the job of assistant cytologist (1940-1945) in John Innes Horticultural Institute, London. In 1945 she along with Prof. C.D. Darlington wrote 'The Chromosome Atlas of Cultivated Plants' in which the information on 1100 garden plant species was given. In this atlas Janaki's own work during her stay in England has also been included. This atlas continues to be useful to many botanists.

In 1945, Janaki began working in the Royal Horticulture Institute as a cytologist. Her most important work on Magnolia flowers due to which she became famous was conducted here. A variety of magnolia she planted is known after her as *Magnolia kobus* 'Janaki Ammal'.

Till 1951 she remained in England and returned back to India on the invitation of the first Prime Minster of India, Pandit Jawaharlal Nehru. The task entrusted to her was to reorganize the Botanical Survey of India (BSI) that was established

A new rose hybrid has been named after former John Innes botanist Janaki Ammal

Magnolia Kobus Janaki Ammal

way back in 1890. Due to Word War II some data was lost and after independence it also became important to organize and manage our own institutes by our own people. Janaki was instrumental in creating four regional branches of BSI in Shillong (east), Pune (west), Dehradun (north) and Coimbatore (south). Her scientific work on evolution of plants, medicinal plants and ethnobotanical plants got a boost for some years. She travelled extensively and sadly witnessed the deforestation taking place. This was one of the reasons that she was against the Hydro-electric project in the Silent Valley in Kerala. Such projects are at the cost of jungles and tribes living there.

> **My being a woman had absolutely no bearing on what I chose to do with my life. What is this hoopla about women and science?**
>
> *– Janaki Ammal*

She travelled to Nepal and Ladakh as well. Her experience and deep knowledge coupled with original thinking enabled her to understand the effect of weather conditions, diversity and proliferation of flora in different regions of Himalayas from north to eastern regions of India. But in spite of her dedication to work along with knowledge and scientific contributions she was not made the director of BSI. Janaki was a little upset as she again had to face gender discrimination and internal politics even at such a senior level. Janaki was very straightforward, simple, would not get involved in gossips and would not approach anyone for favors. But it made her sad. This did not let her stop the research. She was progressing well in her research. She became the fellow of Indian National Science Academy in 1957.

In 1959, Janaki Ammal retired from BSI and was appointed as the Director of Regional Research Laboratory (CSIR) in Jammu. She along with her Ph.D. students focused mostly on ethnobotany and biodiversity. Janaki retired in 1962 but there is no retirement age for those who wish to work! The

Magnolia

Government of India honored her with the Padma Shri in 1977. She lived in Jammu as emeritus scientist for several years. For brief periods she had also worked in Central Botanical Laboratory, Allahabad and Bhabha Atomic Research Centre, Mumbai. She finally shifted to the Centre for Advanced Study in Botany and continued her research as an Emeritus Scientist till her death on February 7, 1984 in Chennai. In her late years she had focused on medicinal plants and ethnobotany.

Janaki Ammal was a very energetic, enthusiastic scientist who loved plants of all types. She worked on foreign and Indian plants with unparalleled interest. It is impossible to count on how many plants she worked!

Her work is of immense value. Janaki Ammal was an inspirational figure of her time and continues to be a role model for young women of all the times and of all the countries. This is evident, as her work is still remembered in India and abroad. In the year 2000, Ministry of Environment and Forestry, Govt. of India instituted an award in Taxonomy in Janaki's name. John Innes Centre in U.K. has started Janaki Ammal Scholarship for Ph.D. students to work in the institute. A beautiful variety of yellow rose bred by a couple Girija and ViruViraraghavan in Pondicherry was named after Janaki. Thus, Janaki due to her focus in work, simplicity and true love for nature overcame the hurdles of caste and gender discrimination. Her name is given to a plant species now known as '*Sonerilia jankiana*' and an animal species of gecko found in India as '*Davidogecko Janakiae*'. Her name is carved in the history of science as the first Indian woman to be a botanist.

Irène Joliot-Curie

DISCOVERY OF ARTIFICIAL RADIOACTIVITY ...

(1897 –1956)

Irène Joliot-Curie is an exceptional example that falsifies the notion that a small tree cannot flourish under a big tree. Her father Pierre Curie and mother Marie Curie, both were Nobel laureates! Irène Curie, grew under the shadow of the illustrious scientist parents but she also won the Nobel Prize for her research work due to her dedication and diligence. While her parents were the discoverers of the natural radioactive elements, Irène, along with her husband Joliot, engraved her name in the history of science by inventing artificial radioactivity.

CHAPTER NINETEEN

Irène Joliot-Curie receiving the Nobel Prize

Pierre Curie and Marie Curie, the world-famous Nobel laureates in physics, had two daughters. Irène was the eldest daughter. Irène was born on September 12, 1897, in Paris, France. The year before Irène was born, the Curie couple had discovered the radioactivity in radium and both had started to come in the limelight. When Irène was 6 years old (in 1903), the Curie couple won the prestigious Nobel Prize but just 2-3 years later Pierre Curie died in an accident by getting crushed under a horse-drawn carriage while crossing the street in Paris.

Irène grew under the care of her mother and grandfather. Her grandfather was a doctor. His rational thinking had a profound effect on Irène. He helped Marie and her two daughters, Irène and Eve, a lot after Pierre's death. Children grasp lots of things in their childhood. In 1907 and 1908, Marie Curie and some of her colleagues organized special camps for school children. The emphasis was on learning from the surroundings, especially by visiting nature. Irène participated in the camps and developed an interest in nature, mathematics and science, since her childhood.

It is very important to understand the significance of science in daily life. It changes a person's perspective. However, a famous person does not have a private life. Moreover, professional jealousy leads to gathering a lot of enemies who do not miss a single opportunity to highlight anything negative in their private lives. Irène experienced this at an early age. Her mother, Marie Curie, was the first woman to win the Nobel Prize, but after Pierre Curie's death, Marie Curie faced considerable difficulties. Although all her research was in France and she had devoted herself to France, she was basically from Poland. Therefore, Marie Curie was an outsider for the French people. Especially the newspapers targeted her, as 'foreigner'. Despite all this, Marie Curie was doing research and focusing on her two daughters.

Ignoring the French press the Nobel Prize committee selected Marie Curie for the Nobel Prize in Chemistry in 1911. Yet, the personal attacks against her continued and Marie Curie was overwhelmed by the criticism and almost collapsed! Irène was only 14 at the time. But she was quite mature for her age. Understanding the situation at the time, she tried her best to support her mother. She did not lose her balance. Her temperament was serious but her confidence was admirable. Marie Curie, however, was fragile and easily got hurt. Irène began to take care of her mother. She happily took over the arrangements of her mother's daily eating, going out and coming back, etc. She was very proud of her mother yet at the same time very different from her mother.

> **That one must do some work seriously and must be independent and not merely amuse oneself in life–this our mother (Marie Curie) has told us always, but never that science was the only career worth following.**
>
> *– Irène Joliot-Curie*

World War I began when Irène was a teenager. It was then that Irène began teaching the methods started by her mother of using X-ray equipment in medical treatment, to hospital staff in the war zone. The work of teaching doctors, nurses and other hospital staff was not easy! In many places, people were reluctant to use such equipment and even threatened to break it. It was a time when X-rays were used for treatment, although the scientists themselves had no idea of its side effects. Irène didn't even understand the effects of handling such equipment, which was affecting her own body!

After World War I, Irène began to work in her mother's laboratory at the Paris Radium Institute as her assistant. At that time, Marie Curie was the director of the Paris Radium Institute. As a result of her constant observation of her mother's work since childhood, Irène was fascinated by the study of radioactive elements. People in the institute used to tease her as 'Crown Princess' or 'Princess' behind her back. But her mathematics and physics were in a way intimidating to colleagues around her. She could not lie to anyone, be sweet, or be polite. She was a very outspoken, straightforward and honest person. But it made many people think that she was dry and secluded.

In 1925, Irène gave her Ph.D. viva-voce. About thousand people came to hear it. The news was covered not only by the French newspapers but even by New York Times of America. After all, it was the main test for the daughter of a world-famous scientist couple! In addition, her parents discovered polonium, a radioactive element found in 1898 and her work on alpha rays was equally important! Irène's Ph.D. supervisor Paul Langevin was also a great physicist.

After getting the doctorate, Irène continued to work at the Paris Radium Institute. In the same year, 1925, a young researcher Frederick Joliot joined the Radium Institute as an assistant to Marie Curie. Frederick Joliot was very clever. His temperament was exactly opposite to that of Irène. He was ever smiling, friendly and decent and could easily mix with all the people. Soon he became popular in the institute. He used to work with Irène in the laboratory. Despite

their different temperaments, Frederick and Irène got along well. He noticed that Irène, who apparently looked hard and dry was very soft, gentle and sensitive from inside. There was however a common thing between Frederick and Irène that both of them loved to wander in mountain valleys and forests. In addition, Frederick Joliot was a big admirer of the Curie couple since his childhood! Everywhere in his room he had clippings of news and photos of Pierre Curie and Marie Curie. Frederick and Irène quickly fell in love with each other and within a few years they were married!

Even after their marriage, Frederick and Irène continued to do research together. At that time, scientists around the world were trying to figure out whether new elements could be created by striking neutrons or other radiation that weighed more than that of uranium (element number 92). Frederick and Irène were also involved in such experiments. However, even after doing 4-5 years of different experiments they could not make much headway. Sometimes even the conclusions they drew were wrong! But in the end, they discovered something entirely different from their expectation! They were using the equipment known as the Wilson Cloud Chamber to study the newly discovered neutron (which weighs as much as a proton but has no electric charge). The activity of a neutron is derived from an electron or a positron (a particle similar to an electron but with a positive charge). But they did not see the necessity of a positron. And once again they made a mistake. But the next experiment they did fetched them the Nobel Prize! This time they placed the radioactive polonium, near the aluminum metal. They found that the neutrons and positrons were coming out of it. It was a strange thing because they expected to get hydrogen from it. But this time they experimented more and also used a device called 'Geiger counter'. With its use, they immediately realized that they had made a new discovery! The reason for the seemingly miraculous activity was that in their experiment, radioactive polonium

Sharers in one of the most famous prizes in the world. Mme. Irène Joliot-Curie daughter of the discoverer of radium, and her husband, Professor Frederick Joliot, who have been awarded jointly the Nobel Prize in Chemistry for 1935 for their synthesis of radioactive elements (Times Wide World Photos, Paris Bureau)

> **The farther the experiment is from the theory, the closer it is to the Nobel Prize.**
>
> *– Irène Joliot-Curie*

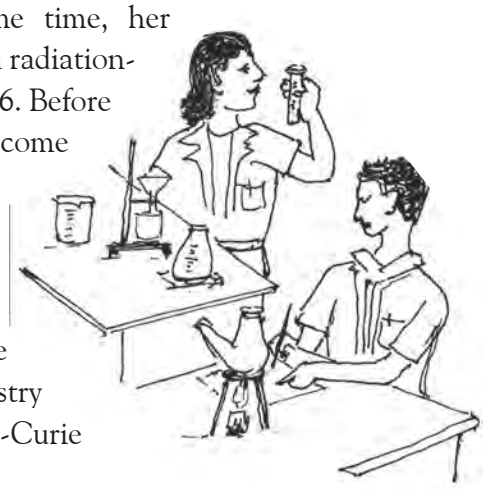
also made aluminum radioactive! Naturally due to this experiment it was possible to make the non-radioactive elements also radioactive. Very few elements are naturally radioactive. So finding them, purifying them and using them was not only difficult but also a costly task. With the discovery that artificially elements can be made radioactive opened up a new area for science and technology.

The discovery, made in 1934, was widely welcomed in the scientific world, and in 1935, Frederick Joliot and Irène Joliot were awarded the Nobel Prize. Irène's mother, Marie Curie, was unfortunately not alive to see the success of her son-in-law and daughter. But she knew before she died about the important discovery made by Frederick Joliot and Irène Joliot-Curie.

A few days later, Frederick Joliot joined the College of France and Irène Joliot-Curie became the director general of the Radium Institute. The French government selected Irène Joliot-Curie as the first female member of the cabinet, even though women still did not have the right to vote!

As the years passed, Irène's health began to decline. The political situation in France, was becoming very volatile. When World War II broke out, Irène and her two young children had to flee from Paris into the mountains of Switzerland. But on the way, she took the physics books with her! For a scientist like her it was a great treasure! When the war ended, she returned to Paris.

In 1956, she was diagnosed with acute leukemia. This could have been the result of radiation exposure. At the same time, her husband, Frederick Joliot, also was dying of a radiation-induced illness. Irène died on March 17, 1956. Before she died, she used to say that her life had become very thrilling and perfect. So she was not afraid of death. Frederick Joliot died two years later. Thus the work on radioactivity which gave fame to the illustrious Marie, Irène and Frederick also became the cause of their death. The Royal Society of Chemistry holds an annual conference called the Joliot-Curie Conference in their memory.



Barbara McClintock

A LONELY SWAN ...

(1902 – 1992)

Barbara McClintock carried out frontline research work without any assistance or collaborations. She was much ahead of her time in her research and of course, because of this, her colleagues did not understand her research or her importance. Due to this she had to suffer considerable instability in her life. But the importance of this unique woman became known to the world when the information on genetics that came from her work on corn, and when her work was publicly described by the Nobel Prize Committee as 'one of the two most important researches on genetics of our time'.

CHAPTER TWENTY

Nobel Prize
(Credit: Cold Spring Harbor Laboratory Archives)

Barbara McClintock was the third of four children of Thomas Henry McClintock and Sarah McClintock. She was born on June 16, 1902, in Hartford, Connecticut, USA. In fact, she was born with the name Eleanor, but her parents soon started feeling that the 'soft' name Eleanor did not suit their daughter and they began calling her 'Barbara'. Barbara's father was a family doctor. As her father's business was not running well, at the age of three she was kept with her uncle in Massachusetts. In 1908 she returned back to Hartford for school. Shortly thereafter, in 1908, the McClintock family moved permanently to Brooklyn, New York.

Since childhood Barbara was introvert. She did not need anyone else's company. Still, her parents let her do what she wanted! They did not mind even if she sometimes skipped off the school and wanted to do something else. Although parents did not oppose her, she and her mother did not get along well with each other since her childhood! Her teachers at school had realized that she was very intelligent and they thought she would become a good professor in some college. But her mother thought that the professors were usually weird! Therefore her mother strongly opposed her getting admitted to a college. She also thought that Barbara would get out of control if she goes to a college. However, her father had no objection in Barbara's education. The mother and the daughter had a huge debate on the issue of college. A few days before the admissions were to close, her father intervened and Barbara's way to college was cleared. Her mother reluctantly let her go to college.

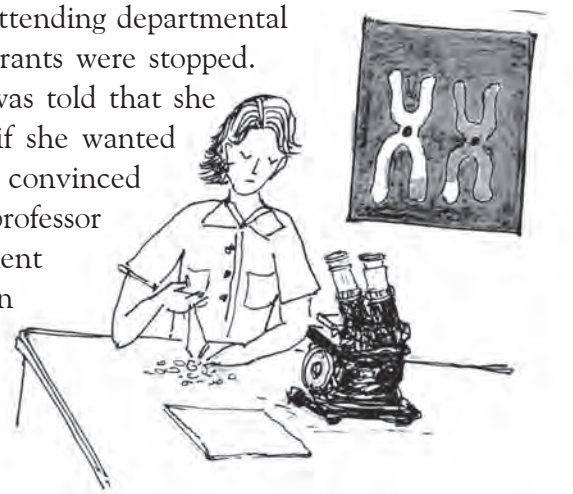
At the age of 17, Barbara entered Cornell University in Ithaca, New York in USA. Gradually, however, away from home, her desire to be alone diminished as she gained the independence. She slowly began to mix up with the students. In 1921, she took her first course in genetics, in which her teacher, Prof. Claude Hutchison noticed her abilities. He advised her to take a degree course in the same subject next year and she listened to him very happily. In 1923, she received B.Sc. degree in agriculture. She became very much interested in plant heredity and decided to study it further. She completed M.Sc. in Botany (1925) and Ph.D. (1927) from the Cornell University.

Barbara then got a job as an instructor in the Department of Botany at the Cornell University. There she got an opportunity to work on cytogenetics. It was her favorite subject. It was the study of chromosomes using a microscope. The study of internal structure of chromosomes was a new direction in research. This is where her research on maize began. She devoted her full time to investigate how corn chromosomes change during reproduction. She studied different varieties of maize. From that, she saw using only an optical microscope how chromosomes

> **It might seem unfair to reward a person for having so much pleasure over the years, asking the maize plant to solve specific problems and then watching its responses.**
>
> *– Barbara McClintock*

divide. She discovered methods of study. She found that staining cells using dyes gives better images under a microscope. With this technique discovered by her she began to see the changes in the cells better than other researchers of the time. The key issue was the understanding of how chromosomes divide during cell reproduction and how genetic information is exchanged (crossover) from both parents. One of her students, Harriet B. Creighton and she published in 1931 some fundamental and valuable work on this subject. Scientist Thomas Morgan had earlier estimated about 20 years ago, how genetic information was exchanged (crossover), but the scientific support to it was provided by Barbara and her student through their experiments.

During the summer vacations of 1931 and 1932, she went to the University of Missouri to learn the technique of dividing cells using X-rays. Then at the age of 31, she went to the University of Missouri as assistant Professor. She remained there until 1941. She continued to work on the corn kernels. During that time she studied the parts of the chromosome, the telomere and centromere. It proved the importance of centromeres in genetics and their function in 1938. But her colleagues did not like Barbara's work style nor they understood the importance of her work. Mary Guthrie, another assistant professor was working on cells, in her department and she used to constantly argue and fight with Barbara. Even the administration was not in favor of Barbara's independent behavior. As a result, she stopped attending departmental meetings. Her university research grants were stopped. Barbara was devastated when she was told that she would not be able to get married if she wanted a job at the university. She was convinced that she would not be a full-time professor there. Besides, the abusive treatment she received was very insulting. Then one day she kicked herself from the job without thinking back and left the University of Missouri and her hard-established laboratory.



At that time, on the one hand, it was sad to leave the laboratory and on the other hand, there was a feeling of relief. In 1941, Barbara took a part-time job of teaching at Columbia University as a 'Visiting Professor'. In 1942, she got a job as an assistant at the Cold Spring Harbor Laboratory on Long Island. Barbara loved the job because she did not have teaching responsibility there and she could devote all her time to research. In just one year, Barbara was offered a permanent job in the faculty. So Barbara was very delighted. Barbara spent the rest of her career in the Cold Spring Harbor laboratory. Better late than never, Barbara had found the job and the co-workers she needed. In 1944, she became a Fellow of the American Academy of Sciences. She was the third woman to receive such an honor from the American Academy of Sciences.

To Barbara McClintock

I don't recall how I came
to love you
Transposed from the jungle to
this strange world of science.
Was it your Cape cod background
as yankee as
Crispus Attucks, as prophetic?
Was it controlling elements
in genes or politics?
Was it my childish amazement
of playful DNA,
Jumping around in evolution,
The subtle experiment of nature?
Was it the pulse I discovered in
Protoplasm,
Until the virtue came along,
Controlling without breath,
Transforming without
consideration?
No! It was your selfless courage
To insert new constructs
into the mystery
And to remind us, to never cease questioning.

–Ricordo O. Fitten

Barbara also continued research on chromosomes and heredity in corn kernels at Cold Spring Harbor. The main issue was that along with the heredity acquired from the parents, how the conditions, mobility, the weather also affect the breed (controlling element). This new aspect was unveiled to the scientists after Barbara's investigations. This is considered to be her greatest contribution. Barbara's work shows how a single subject can be handled by each researcher in a different way and also that one can continue to work lifelong on a seemingly small subject. Barbara was extremely focused in her work. In 1950 she started publishing this work. When carrying out research on a new topic, it was necessary to consider and verify all the aspects and its consequences. Usually other scientists reject an incomplete, experimentally unsupported or unverified research report. Therefore, it is necessary to publish the work that has passed all the tests. Barbara's method of publishing the research work only after completing all the related work is worth emulating.

In 1951, based on her work of discovery of genes controlling element Barbara delivered a lecture to eminent university professors at a summer camp in Cold Spring Harbor. The cold response that she received for a fact she considered so important, frustrated her and she stopped publishing her work. In 1960, when Francois Jacob and Jack Monod began publishing their research on the genetics of bacteria, Barbara saw similarities between the genetics of bacteria and corn kernels, and she published her research article. Gradually Barbara's research began to gain importance. Her research led to the subject of 'genetic engineering'.

In 1971, Barbara was awarded the National Medal of Science by President Nixon. In 1981, she was awarded the Thomas Hunt Morgan Medal. She also received the Louisa Gross Horwitz Prize in 1982. In 1983, unexpectedly, she was awarded the Nobel Prize which is the most prestigious award in the scientific world. The award for the medical subject of physiology was given for her discovery of a 'mobile genetic element'. She is the only woman to have been awarded the unshared Nobel Prize. Her research was described by the Nobel Prize selection committee as "one of the two most important research on heredity in our time". She has since received several big and small prizes. She got a lot of publicity that she deserved. She was awarded the honorary degree of Doctor of Science (D.Sc.) by 14 universities. In 1986, she was inducted into the National Women's Hall of Fame.

Barbara died in Huntington, New York, on September 2, 1992, at the age of 90. Her private life was quite lonely. She was neither married nor had children or friends. She had always preferred to be alone. That was the secret of her concentration. But it is a fact that despite living a different life in the society, she made a great contribution in life. Although she was considered by some of her colleagues as ugly duckling swimming separately in the pond, they did not realize that she was a beautiful swan engrossed in its tranquil heavenly journey!

This ear of corn was grown and analyzed by Nobel Prize-winning Cold Spring Harbor Laboratory (CSHL) geneticist Barbara McClintock decades ago. From her observations, she surmised that parts of the corn genome jumped from one location to another, generating a great deal of genetic diversity—in this case many different colors of kernels. CSHL researchers expanded on her work by sequencing the genomes of multiple corn strains, mapping even the mobile portions of the genome. (Credit: CSHL Library & Archives)

Maria Goeppert-Mayer

DESIRE TO KEEP LEARNING...

(1906 – 1972)

Only three women have won the Nobel Prize in Physics so far (1901 to 2022). The first was Marie Curie in 1903 and Maria Goeppert-Mayer in 1963 and third was Donna Strickland in 2018. Maria Goeppert-Meyer is also the first woman to win the Nobel Prize for her research in nuclear physics, as well as in theoretical physics. Although the home environment was academic, she had to deal with gender discrimination in universities. Intelligence coupled with thirst for knowledge about new things paved the way for her winning the Nobel Prize in 1963.

CHAPTER TWENTYONE

Mayer Hall-library-Mayer Hall in 1964. First occupied in 1963, the building honours former UC San Diego professors Maria Goeppert-Mayer and Joseph Mayer.
(Credit: Robert Glasheen Photograph Collection, Special Collections & Archives, UC San Diego)

Maria Goeppert-Mayer's maiden name was Maria Goeppert. She was born on 28th June 1906 in the village of Katowitz in Germany, but now in Poland. She was the only child of Friedrich Goeppert and Maria Wolf. So it was no wonder that her parents wished Maria to follow the family's professional tradition and become a professor. Friedrich Goeppert himself was the sixth in the generation of professors in his family! He was a pediatrician. When Maria was four years old, her parents moved with her to Göttingen, then known as the 'Mecca' of physics in Germany. If there are scholars in a town or city, it influences the thinking of the young and the old population in it. The University of Göttingen was famous not only in Germany but also the world over it was considered to be a leading university. Many great scientists used to visit it. Göttingen was thus a home of learning!

Although Maria's schooling was effortless, as a woman her admission to the university was not easy. Admission to the university required 'abitur' or secondary school qualification in Germany. But when she wanted to give the abitur examination, the high school in Göttingen, which was for the girls, was closed down. But without hesitation, she made her way through Hanover! She took the examination there and in 1924 she was admitted to the University of Göttingen. At that time, 'Quantum Mechanics', an important branch of physics today, was emerging. Maria received valuable guidance from Max Born, a major contributor to Quantum Mechanics. Max Born was awarded the Nobel Prize for physics in1954. She carried out research on a new theoretical topic known as 'Quantum Double Photo Emission'. Further in the nebula and elsewhere such type of photoemission was found to be taking place. A similar process occurs when laser beams are emitted. In 1930, Maria received a doctorate for her dissertation submitted to the University of Göttingen. Her all three judges were Nobel Laureates – James Frank (1928), Adolf Otto Reinhold Windhaus (1924) and Max Born (1954). Later in her honor, the unit of cross section (possibility) of double photoemission has been termed as GM (Goeppert-Mayer).

In 1930, Maria married Joseph Edward Mayer, an American chemist who had been visiting the University of Göttingen as a Rockefeller Fellow for some time. She and Joseph Mayer had two children, Maria Ann and Peter Conrad. At the University of Göttingen he worked with James Frank. He himself was a budding scientist. Jobs were few in Germany at that time. It was especially difficult for women to get a job in a university. Thinking that things would get better in the United States, they decided to move there. Joseph and Maria moved soon in 1930 to the United States. There, Joseph Mayer got a job as an assistant professor at

> **Mathematics began to seem too much like puzzle solving. Physics is puzzle solving too, but of puzzles created by nature, not by the mind of man.**
>
> *– Maria Goeppert-Mayer*

Johns Hopkins University. But the administration refused to give her a job at the same place. This practice still continues in many places today. As a result, well-educated young women have to undergo a feeling of dejection, because men are always preferred to do the job. But after some efforts, she was allowed to work at the university without pay. From Maria's point of view, it was 'better than nothing'. She had to work in a cramped room! Yet without fail, due to her sheer love for physics she used to go to the University. Gradually the people in the department began to understand her knowledge and her proficiency in the subject and allowed her to give lectures in the Department of Physics, though unpaid! During her nine years at Johns Hopkins University, Maria co-authored 10 research papers in physics with Joseph and Carl Herzfeld. In fact, when Maria was not paid for her work and did not get special honors, she could have as well stayed at home! She was often thought of as 'the wife of a professor' without getting credit for her proficiency. But her faith in her work was unwavering. She had accepted the path of working in whatever situation she could, regardless of what was going on.

In 1938, Maria's husband Joseph went to Columbia University and she followed him, although she was a bit settled in the Johns Hopkins University. The Department of Physics at Columbia University also refused to take her. But chemistry department gave her a small office to sit in and allowed her to take a few lectures without pay. In fact it was much less than what she deserved. However she was so fond of research that she accepted whatever was given to her! While in Germany itself Maria had lost her confidence and started smoking cigarettes. Now the habit of smoking had increased a lot.

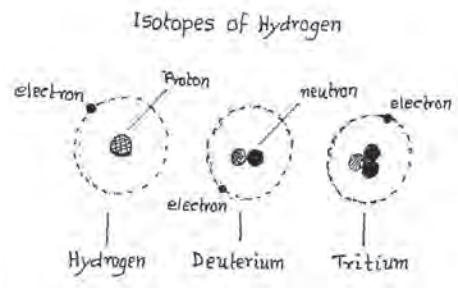
Fortunately, Maria soon began to receive a salary. She also had the opportunity to participate in a uranium enrichment project. After the end of World War II in 1946, many famous scientists came to the University of Chicago. There, however, for the first time, Maria got the respect she deserved. As a result of World War II, the salary was rather low. But there was an opportunity for her to be in association with many eminent scientists working on the 'cutting edge' research that was going on. One of her old student invited her to work in nuclear physics at the Argonne

National Laboratory. She could also simultaneously teach at the University of Chicago. At that time she did not know much about nuclear physics. But when her student showed trust that she could do it, she agreed. Enrico Fermi, known as the 'father of the world's first nuclear reactor' and the 'architect of nuclear energy', as well as Edward Taylor, the 'father of the hydrogen bomb,' helped her to understand the subject of nuclear physics.

Maria started working on isotopes. Isotopes are atoms of different weights of an element. For example, the element hydrogen has three isotopes of different weights, hydrogen, deuterium and tritium. All three isotopes have the same atomic number, which is attributed to a single proton existing in all these isotopes. Their weights vary with the number of neutrons in their nuclei. The nuclei of hydrogen, deuterium and tritium contain only one proton. But deuterium has one neutron with one protons, while tritium has two neutrons and a proton. Maria found that some of the nucleons with 2, 8, 20, 28, 50, 82 or 126 number are stable. Later a famous scientist Wigner called them 'magic numbers'. Maria wondered why some isotopes were more stable than other isotopes of the same element. Magic numbers exist even in atoms. They are of atomic number 2 (helium), 10 (neon), 18 (argon), 36 (krypton), 54 (xenon) and 86 (radon). Maria established the 'atom shell model' for the stable isotope of atoms. She was able to explain the magic numbers, the explanation for their existence, and how nuclear pairing works. At that time J. Hans D. Jensen, Otto Haxel and Hans Suess were also working on it. Maria Goeppert-Mayer, J. Hans D. Jensen, and Eugene Wigner were awarded the 1963 Nobel Prize in Physics for the nuclear shell structure. Learning a new subject and contributing to it is not an easy task! Maria explained the reason for the stability of isotopes in a way that a layman can understand in simple language. She compared the model with a western dance type 'Waltz'. There are concentric circles in which protons and neutrons in nucleus pairs orbit around each other. For that, they need less energy. Even when dancing around each other, dancing becomes easier because that requires less energy!

In 1960, 3-4 years before the Nobel Prize was awarded to Maria, she was offered professorship by the University of California, which she accepted. Perhaps knowing

that, the University of Chicago also offered to give her a professorship. But she turned down the offer. It seemed ridiculous for her to get this offer after so many years of unpaid work in the University of Chicago. So she joined the University of California in 1960. But Maria's health had deteriorated by now. Still, she never gave up. She used to say, 'If you love science, you really only need work'. When one of the Indian student who joined her in 1963 as a post-doctoral fellow asked her on which research problem he should work, she gave a very interesting answer. She said: 'I have two research problems. If you work on the first one, you will definitely be able to solve it and publish the work. Other problem is a challenging one of which I myself do not know the answer! You can choose to work on either of them.' In life one needs to take challenges, particularly it is most important in research.



Unfortunately, Maria suffered a heart attack, just after a few days after moving to California. Her health never improved much, and she died on 20th February 1972 at the age of 65. University of California honored Mayers by renaming a building after her as 'Mayer Hall'. An annual women's conference on current science was also started in her name. The American Physical Society began awarding the annual Maria Goeppert-Mayer Prize in her honor to a woman scientist who has excelled in physics. The award-winning scientist is also given financial assistance to go to 4 other important institutes and give lectures. The Argonne National Laboratory also gives in Maria's name an award to a young woman for her outstanding work in science or engineering. NASA has named a 35 km diameter crater on Venus as 'Goeppert-Mayer'. In 2011, Maria was included in the third series of 'American Scientists' by American Post. Although the Nobel Prize brought Maria Goeppert-Mayer to the limelight, she has also made other significant contributions in physics and chemistry. The book 'Statistical Mechanics' written by her husband Joseph Mayer and Maria (around 1935-36) is considered a 'classic' book on the subject and was used as a textbook for many years. The University of California has preserved all of her work in their 'Giselle Library'. In this way, even though in her life for a long time, Maria did not get even a simple decent salary, she finally got her 'compensation (?)'. Her tireless work, passion for research, and her husband Joseph Mayer, who understood her well and respected her, played a major role in her achievements. Her personal life was happy too.

Rita Levi-Montalcini

Adventurous Scientist ...

(1909 – 2012)

On April 22, 2009, Italian Nobel Laureate Rita Levi-Montalcini celebrated her 100th birthday in Rome. She was the first Nobel Prize-winning scientist to reach 100. She was awarded along with her colleagues the Nobel Prize in Physiology or Medicine in 1986. Rita's journey to the Nobel, is very adventurous. During World War II, she could not work in a university laboratory because she was a Jew, so she installed a laboratory of her own in her bedroom. When the eggs needed for the experiments were not available, she cycled to nearby villages and went shouting, 'My children need eggs' and begged. The life story of Rita Levi-Montalcini is very thrilling!

CHAPTER TWENTYTWO

Rita Levi-Montalcini receiving the Nobel Prize, 1986

Rita Levi-Montalcini, a Sephardic (a branch of Jews) Jew, was born on April 22, 1909, in the village Turin, Italy. She had an elder brother, sister and a twin sister. Her mother, Adele Montalcini was a painter, and her father, Adam Levi, was an electrical engineer and mathematician. As a teenager, Rita wanted to be a writer. She was overwhelmed by the story of Selma Ottilia Lovisa Lagerlöf, a Swedish writer. Selma was the first woman author to win the Nobel Prize for Literature. But after seeing a close family friend die of stomach cancer Rita decided to study at Turin Medical College. Rita's father did not like the decision. He thought that if the girls learned a lot, it would have a bad effect on the family life. He felt that education of a girl would hinder her future in the family as a wife and mother. This kind of conservative thinking was very common in the society at that time and her father was not an exception! But Rita's decision was firm. Rita went further and declared that she would not ever get married! She was so adventurous and determined that she kept this decision for the rest of her life and never regretted it. She used to say that her research work, work colleagues and friends never made her feel lonely or that she did not have anything further to gain in life.

While in the medical college in Turin, Rita was introduced to the field of neuroscience by Professor Giuseppe Levi. Giuseppe Levi was a very good professor. He himself had done some basic research on cells and was very good in teaching physiology. In addition to Rita Levi-Montalcini, two of his students also received the Nobel Prize!

In 1936, after graduating as M.D. (medicine) from Turin Medical College, Rita began to work with Levi in the physiology department as his assistant. She was good at research. But in 1938, the Italian government banned the Jews from working in the medical and research fields. As a result, Rita lost her job in the college and was unable to do research. But Rita was not a person who would get defeated by any situation and stop her research. She always found some solution!

Growing up, Levi-Montalcini fought her father to be able to attend medical school.
(Credit: SPL & https://www.nature.com/articles/458564a

Around the same time, Rita's reading included some research by Viktor Hamburger, a scientist working in neurobiology at the University of Washington, St. Louis, USA. Viktor Hamburger, using a chicken embryo had begun to look at the

> **The love for nerve cells, a thirst for unveiling the rules which control their growth and differentiation, and the pleasure of performing this task in defiance of the racial laws issued in 1939 by the Fascist regime were the driving forces which opened the doors for me of the "Forbidden City".**
>
> *– Rita Levi-Montalcini*

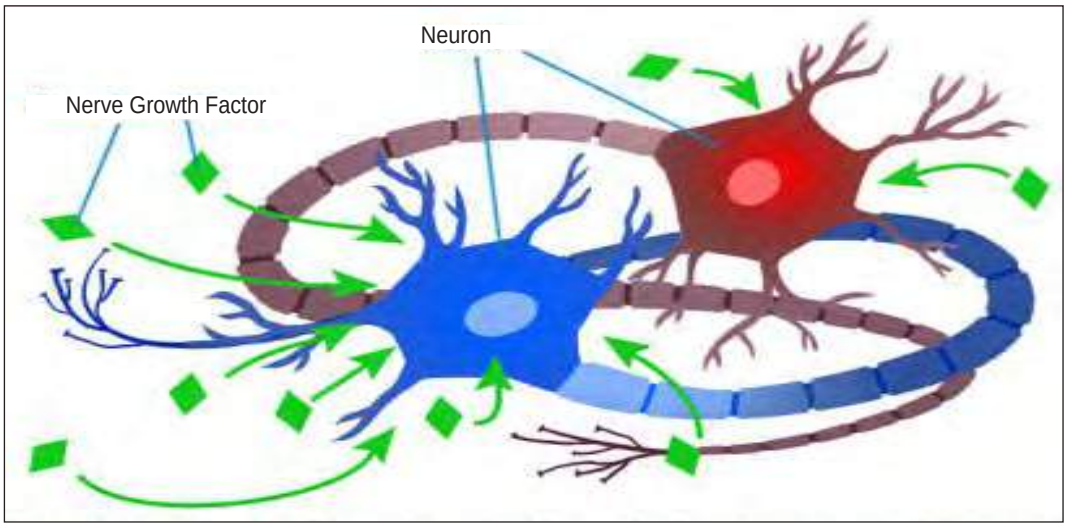
relationship between the spinal cord and the growth of the nervous system. St. Louis is a city on the Mississippi River in the United States. It was very difficult to get there during the World War. There was no possibility of getting anyone's research guidance or discuss the work with anyone. If the news had come out that she was doing some research, she would have been straight away sent to jail! Even in such a difficult situation, Rita found a way. She decided to seek help from her family, and they all generously extended it to her.

Rita secretly set up a small laboratory in her own bedroom. Her elder brother, Gino, was a professor at the University of Turin. He helped her in a number of ways. Of course in some experiments she needed to dissect the fetuses (eggs) of the hens. For this, she made scalpels from the knitting needles. She collected microscopic tools used in making watches and fine scissors used in eye surgery. In this way her laboratory was ready! But she needed eggs for the experiments! Due to war there was a food scarcity everywhere. So, to get eggs for research was very difficult. Rita thought of using a trick. She went on cycle to the surrounding villages and begged the people saying 'please give eggs for my hungry children'! She needed mature eggs for research! While studying the different stages of hen's fetus, she also took an assistant researcher to work along with her. She broke the backbone of the fetus into fine pieces. From that she learned some new things. There was a belief that nerves do not grow much. But she found that as the fetus develops, the nerves, like other cells, grow and

then die. But even this work could not go as straightforward as it seemed. When Germany occupied a part of Italy in 1943, she had to flee to Florence with her family. But even there, she set up her lab in a corner of the house. Later, in 1945, Rita returned to Turin with her family.

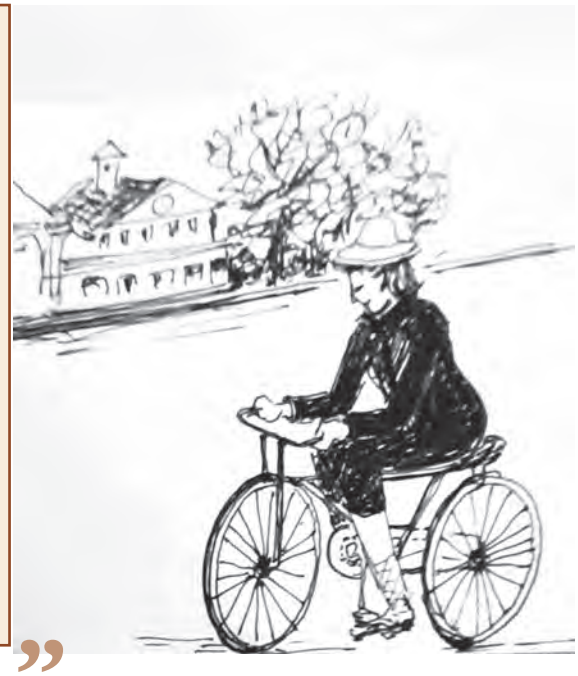
It was during the II World War that Rita published some of her research in various journals in Switzerland and Belgium. These journals also went to America. Viktor Hamburger from whose work Rita had received inspiration read her papers. He appreciated her work, and in 1946, after the end of World War II, he invited her to work with him for six months. After the war it was not forbidden to go out of the country or do research. The situation had changed a lot by now. Getting to work with Viktor Hamburger was a golden opportunity for Rita. After many years, her dream was coming true. So she immediately accepted Hamburger's invitation and immediately left for America! Her only concern was to do a lot of work. Rita had decided to return to Italy after six months of hard work. But the six-month stay extended to as long as thirty years! Rita spent many years at the University of Washington, St. Louis. After re-examining the work, which she had carried out at home in a small laboratory, Hamburger hired Rita as a research associate in his laboratory at the university.

Rita's most important work gained momentum from 1952. Rita travelled to Mexico to learn how to grow cells in a glass dish. In one such trip to Mexico, she put a pair of chicks in her purse! She herself knows how she 'managed'



Nerve Growth Factors (shown in green) are required by neurons in order to survive. As they are a limited extracellular resource some neurons (shown in blue) may uptake a disproportionate share of survival factors, leading to the eventual death of neighbouring neurons (shown in red).
(Credit: http://www.fmboschetto.it/didattica/lascienzaedonna/Rita_Levi_Montalcini_Bianchi_Zanon.pdf)

> It is imperfection—not perfection—that is the end result of the program written into that formidably complex engine that is the human brain, and of the influences exerted upon us by the environment and whoever takes care of us during the long years of our physical, psychological and intellectual development.
>
> – *Rita Levi-Montalcini*



In the laboratory

(Credit: https://metode.org/issues/seccions-revistes/histories-de-cientifics-seccions-seccions/rita-levi-montalcini-jewish-woman-and-scientist.html)

it, as passengers and their luggage are thoroughly inspected before boarding a plane! Once there was no seat available on the plane, then she 'convinced' the pilot (!) and sat in the cockpit as his co-pilot. Rita's skills in finding a way out of any situation were overwhelming! But the fruits of such adventures did not seem to come easily. Somehow the growth of nerves in rat cells did not appear to be happening. Days, months and years were passing in the swing of hope and despair. But without giving up, Rita was thinking and experimenting differently. She tried to understand the mechanism of growth of some cancerous tissues. It made it easier for her to understand how the nerve growth factor could be. In a similar experiment, Rita inserted tumor fragments into a hen's egg and found abundance of the nerves. Rita and her colleagues were amazed to see the cells growing around the tumor like radiance. This type of nerve growth was never been seen before. She noticed that these nerves were moving to new places to form new cells. The nerves also travelled through the veins, but the nerves did not spread through the blood vessels emerging from the egg embryo to the tumor. This proved that the tumor itself causes the growth of nerves. In recognition of her research, the University of Washington awarded Rita the position of Professor.

In 1962, Rita started another laboratory in Rome, Italy, and began working in both Rome and St. Louis! From 1961 to 1969, she was the director of the Neurobiology Research Center in Rome, and from 1969 to 1978, she was director of the Cellular Biology Laboratory. In 1986, Rita, along with her colleague Stanley Cohen, received the Nobel Prize for their research on the Nerve Growth Factor (NGF). In 1990, she became the first scientist to show the importance of mast cells or labrocytes in human blood. In 1992, she also showed the existence of a compound in the same cell called palmethylthanolmide.

In 2001, Rita was given the title of Senator, for lifelong, by the President of Italy. On April 22, 2009, her 100th birthday was celebrated in Rome with great fanfare. She was the only Nobel laureate to reach 100 at that time!

Rita Levi-Montalcini passed away on December 30, 2012 at the age of 103 at her home in Rome. Rita's longevity may have been due to her hard work, never complaining, lively, adventurous and happy life by adapting to any situation. She was so accustomed to being neat and well-dressed that once she lost her luggage on a flight and immediately had to give a lecture. She had no clothes to change at that time! So she preferred to give a lecture by wearing an ironed gown kept for sleeping in a hotel rather than wearing crumpled clothes! It is no wonder that Rita's fame had spread everywhere. It was jokingly said in Italy that if Rita and Pope stood side by side, Pope would be known because of Rita.

Rita Levi-Montalcini was the first Nobel laureate to live over 100 years of age

Rita Levi-Montalcini received many prestigious awards. In 1966, she was elected a Fellow of the American Academy of Arts and Sciences. She became a Fellow of the United States National Academy of Sciences in 1968. She was only the 10th female scientist to become a Fellow of the United States National Academy of Sciences. She became the member of Pontificial Academy of Sciences in 1974. Columbia University in the United States awarded her the Louisa Gross Horwitz Prize in 1983. In 1986, she received an award for basic medical research. Rita received the National Medal of Science in 1987, the highest award for science in the United States. Although she was Italian by birth, she had worked mostly in America. Rita also received the highest award in the United States as she was well integrated there. In 1991 Trieste University in Italy honored her with the Laura Honoris Cosa in Medicine award. In 1995, as a foreign scientist she received an honorary membership of the Royal Society of England. She was appointed, Goodwill Ambassador by the United Nations Food and Agriculture, in 1999. In her hometown, the Polytechnic University of Turin she was given 'Laura Cosa in Biomedical Engineering' degree. In 2008, the Computons University in Madrid, Spain awarded an honorary doctorate to Rita. One can say that the longevity that Rita Levi-Montalcini had has been worth living in a way that the great scientist like her lived!

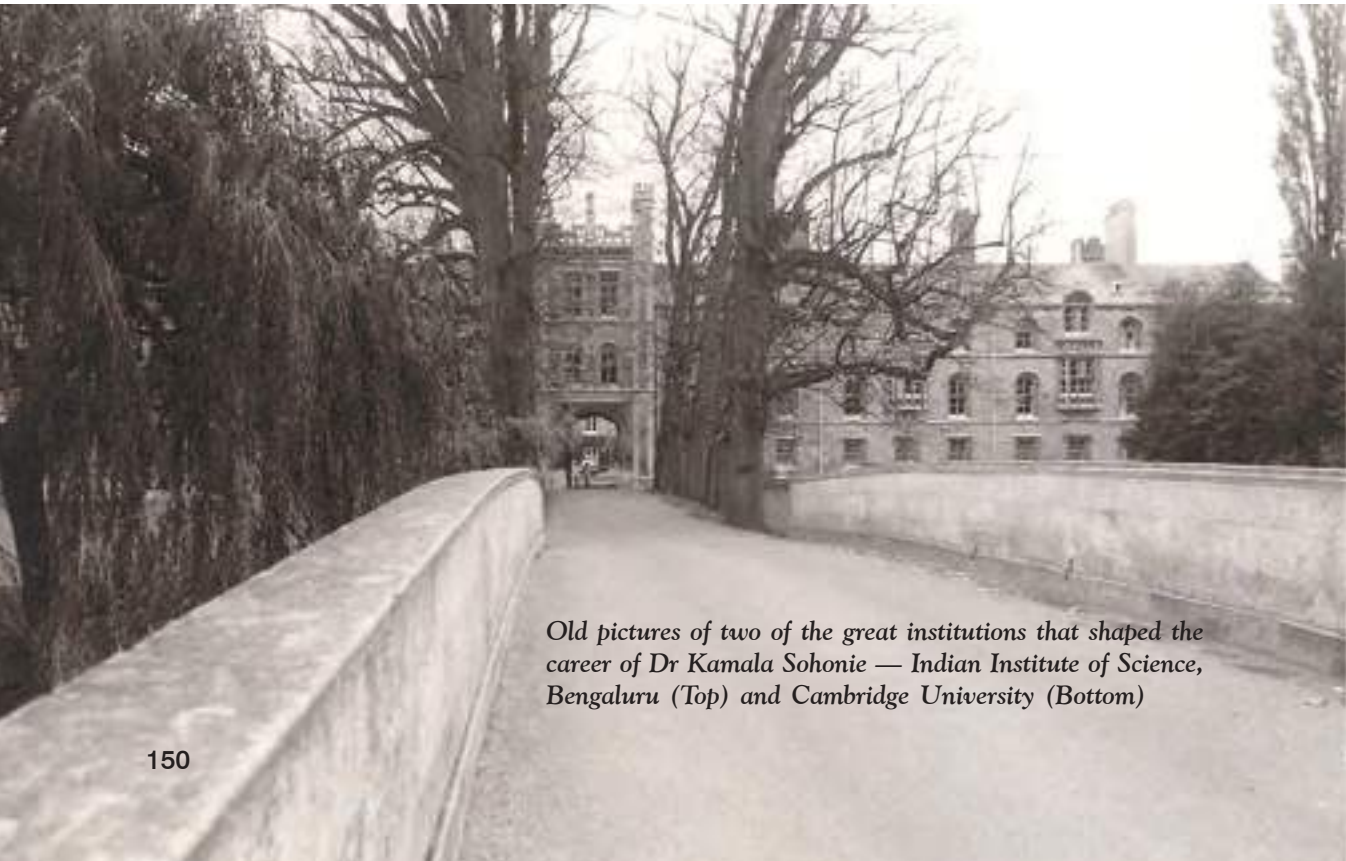
Kamala Sohonie

INDIA'S FIRST FEMALE SCIENTIST ...

(1911 – 1998)

Even after securing first class and first rank in B Sc, from Bombay University, Kamala Sohonie was denied admission to the Indian Institute of Science due to gender bias. Talking directly with the then director Nobel Laureate CV Raman she convinced him how wrong it is to deny admission to women. Convinced by her example that given the opportunity women also can work hard and contribute to research, the Institute started admitting girls from the following year. After post-graduation, Kamala earned her Ph D from Cambridge University, UK. Thereafter she carried out a lot of research and socially important work in India.

CHAPTER TWENTYTHREE



Old pictures of two of the great institutions that shaped the career of Dr Kamala Sohonie — Indian Institute of Science, Bengaluru (Top) and Cambridge University (Bottom)

Kamala Bhagvat was born on June 18, 1911 in Indore in a very educated family. Her father's name was Narayan Bhagvat and mother's name was Mathura alias Lakshmi Bhagvat. Kamala's father was a chemist. He did research on oil and fat at the Institute of Science, Bangalore and later worked in Mumbai. In those times women did not get any education but Kamala's mother was educated up to matriculation. Narayan and Lakshmi Bhagvat had four children (three daughters and a son). Kamala was the second child. Her elder sister is the renowned Marathi writer Durga Bhagvat. Kamala's parents never discriminated between son and daughter. As a result, all four of their children grew up to be modern and free thinkers.

Unfortunately, at the age of nine, suddenly Kamala lost her mother. One of her aunt (father's sister), then took care of the girls. She herself also was well educated. She was entrusted with the task of running an English school for girls at Ahmednagar, Maharashtra. The three girls went to Ahmednagar with their aunt and started studying in their aunt's school. The aunt did not let them feel the void created by their mother's death.

After matriculating in 1929, Kamala returned to Mumbai and started studying at St. Xavier's College. Kamala was soon known as a very smart and intelligent student. In 1932 she passed B.Sc. in Physics and Chemistry with first class and first rank from the Mumbai University. Therefore, she also got the 'Satyavati Lallubhai Samaldas' scholarship for higher education. Following in her father's footsteps, she wished to conduct research at the Institute of Science, Bangalore. Kamala decided to do research and get a master's degree. For this, she informed the institute in 1933 about all her educational details. She thought that with her excellent educational achievements so far she would easily get the admission. However, she received a letter from the institute saying that she could not be admitted! Her father too was shocked to see that. How can an intelligent, talented girl like Kamala not get admission in an organization in India, of which Nobel Laureate Raman was the director? He decided to meet Raman and get the issue of the admission resolved. Kamala and her father Narayan Bhagvat immediately departed for Bangalore.They met the great scientist and director, Sir. C.V. Raman with considerable tension. But Kamala's father simply raised the question. 'Sir, was Kamala denied entry by some mistake? Raman said 'No mistakes are made in this institution. She was not admitted because she was a girl. We don't want girls here. Research is not their field of work!' Neglecting that she was talking to a great person, Kamala fiercely interrogated him 'What is wrong with me Sir? Even after appearing first in the university amongst boys and girls, why is it unfair

to the girls. What are deserving girls like me supposed to do if you deny me admission?' She further exclaimed that 'I will do satyagraha (a strike for justice) and sit at the gate of the institute till I get admission'. Raman was taken aback to see her warrior (ranaragini) like confrontation. He immediately resolved to admit her on one condition! He asked Kamala to produce high quality research in one year and if that work was approved, she could continue.

Kamala accepted the challenge. As she wished to work in biochemistry, Prof. Raman arranged for her research in Dr. Subramaniam's department. Before Kamala reached the biochemistry department, her discussion with Raman had spread all over the institute. Therefore, Dr. Subramaniam and his fellow professors-researchers thought that Kamala Bhagvat must be someone with an aggressive nature. But they were all pleasantly surprised to see a soft, calm and polite girl in front of them. Dr. Srinivasaya, one of Dr. Subramaniam's colleagues agreed to guide her in research. Dr. Srinivasaya was a meticulous, very punctual and diligent researcher. He also told her in front of her father before taking Kamala to work with him that he also had some conditions while taking her! His first condition was that she should work in the laboratory from 5 am to 10 pm and the second condition was that she should do the work she was told to his satisfaction. Kamala's father was terrified to hear the conditions put by Dr. Srinivasaya. When will the girl eat, he thought? But the difficulty was easily taken care of by Dr. Srinivasaya. For he arranged for her meals, saying that a lunch box would come from his house. He didn't want his student to waste time in cooking. Moreover, according to the director Raman's terms, she was expected to make progress in one year and complete her master's degree in just one year! This meant that the work that the other students were completing in two years was to be finished by Kamala in half the time! That doubled Kamala's work!

Kamala was not afraid of work. She did not want to miss the opportunity. She just asked for two hours a day to play tennis. Exercise was essential for good health. Dr. Srinivasaya agreed. Kamala played tennis every afternoon from 4 to 6. It was her favorite hobby. Kamala used to go to the lab at 5 am in the morning and work there till 10 at night always with a smiling face. Dr. Srinivasaya was very happy seeing her way of doing a good work without complaining anywhere. During the first 3-4 months, Kamala studied the methods and equipment required for research in chemistry. After she became proficient in it, Dr. Srinivasaya asked Kamala if she wanted to start research with him now, Kamala was happy. He asked her to separate the cereals and milk proteins. He also wanted to find out the types of acids in them. She also had to study different types of milk such as mother, cow,

goat, buffalo and decide which ones are easier to digest. The same goes for cereals. Kamala made a complete study of even the broken grains by chemical separation of different cereals like green gram, matki, dried peas, lentil, chawli. She was having good success in her research. Most of the year went well. Kamala went to Raman and she asked him straight away whether she should continue to work or go back home now? Raman used to watch the progress of all the students. Therefore, it was natural to pay extra attention to the 'girl' who had been admitted with a challenge! He had got the reports of her hard work and love for work. He knew her research progress very well and was happy that she worked well. Kamala was living in the premises of the organization and Raman's wife used to look after her like a guardian. So Raman realized that it was his fault that she was initially denied entry. Raman certainly had the greatness to realize his mistake and was generous to change his policy. He not only praised her but also decided to admit deserving girls to the institute. According to it, two new girls were admitted in 1934. In this way, Kamala laid a foundation by doing her own hard work. She became a role model for women in the true sense of the word. According to the policy of the Indian Institute of Science those days, one could submit the dissertation for the degree based on the research carried out in the institute to any University. Kamala submitted her dissertation to the University of Mumbai and in 1936 she received the M.Sc. (Master of Science) degree. After that, Kamala started looking for a doctorate. She would have liked to do further work with Dr. Srinivasaya, but Dr. Srinivasaya himself went to Europe for a year, so she had to work elsewhere.

> **"Though Raman was a great scientist, he was very narrow-minded. I can never forget the way he treated me just because I was a woman. Even then, Raman didn't admit me as a regular student. This was a great insult to me. The nias against women was so bad at that time. What one can expect if even a Nobel Laureate behaves in such a way?"**
>
> *– Kamala Sohonie*

Facing many difficulties in 1937, Kamala went to meet the director of the Sir William Doon Institute of Biochemistry in Cambridge, England, Nobel Laureate

Prof. Hopkins. She got the opportunity to do research with Derrick Richter in his organization. Sir William Doon Institute of Biochemistry was a very prestigious institution and it was not easy to get admission there. But considering Kamala's adventures and her previous research, Prof. Hopkins and Dr. Derrick Richter decided to give her a chance. There in Cambridge too she had to work day and night. But Kamala, who was fond of research, was happy with the arrangements there. Sometime later, Prof. Richter left for London, and she began work with Prof. Robin Hill. She started work on the hormones involved in the oxidation of potatoes. In doing so, they found 'cytochrome C' to be at the center of the potato's respiratory tract. It was such an important discovery that Kamala and Robin Hill immediately with full evidence sent their research article to a very important, prestigious journal, 'Nature'. Nature also immediately published the research. Shortly afterwards, Kamala submitted her dissertation in 1939 and returned to India with a doctorate in biochemistry.

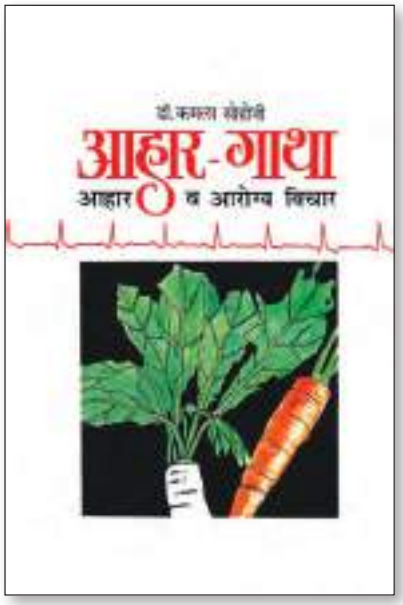
Kamala's journey in science is a story of endless difficulties. Even after returning to India due to World War II, she had to face many challenges with few rays of hopes. When she came, she was appointed as the head of the biochemistry department at Lady Hardinge Medical College in Delhi. Her work was to teach the girls and take their practicals. She also had to check blood samples at Lady Hardinge's Hospital. But most of all, she did not get time to do the research, which was her main goal. She felt a little bit of relief when she got recognition as a research guide from Punjab University. Her student Sushila Nair received her Doctor of Medicine (M.D.) degree from the Punjab University. Still doing full time research, which was Kamala's wish was not fulfilled. It was completed when she soon got a job as the Assistant Director at the Indian Institute of Medical Research (ICMR) at Coonoor. Here she had many responsibilities. As Kamala was learning new things, she was very happy and cheerful. There she had an opportunity to work on the subject of nutrition. The important effect of vitamins on animals was handled by Kamala. Especially she did important research on vitamins B and C and their need. Although Kamala had enough research experience, as she was a female research scientist, all male colleagues did not like her being there, she was denied the position of Chief Director. However, she did not let all this interfere with her research. A real passionate scientist always prioritizes his/her research without caring for money, position, prestige, or fame.

Around that time when Kamala was in Coonoor, Mr. Madhavrao B. Sohonie proposed to her for marriage. When Kamala was doing her B.Sc., he was also studying in her college in Mumbai. Ever since then, he liked her and had respected

her for her accomplishments. Later, he also saw Kamala in a ceremony. He went straight to Coonoor and met Kamala. Kamala also liked his hard work, thoughtfulness and flamboyant personality. However, since Madhavrao Sohonie would be staying in Mumbai and was not likely to get anything in Coonoor, Kamala decided to go to Mumbai after marriage.

After getting married on September 4, 1947, Kamala started living in Mumbai. Kamala and Madhavrao Sohonie's family life became very happy. They had two sons and they were properly educated and nurtured. Kamala had no room for complaint. She also did not step back in research as planned. In the month following her marriage, in October 1947, she accepted the post of 'Assistant Public Analyst' in the Mumbai Municipal Corporation. She used to check samples of food and beverages in restaurants and shops in the city. But she was not interested in this 'routine' work. Therefore, in June 1949, when the Government of Maharashtra started a new science institute, Kamala was appointed as the Professor of Biochemistry and got the right job. Due to the approval of this department by the University of Mumbai, there were 10 students admitted for M.Sc.. There, Kamala set up the first state-of-the-art, well-equipped laboratory and began research. There she spent many years on in-depth research of the Indian drink 'Neera'. By studying in detail the, dates, palms and palm kernels, she found how much potassium, calcium, riboflavin (vitamin of the B complex) and sugar was in them. She proved that Neera contains sugar, iron, calcium, riboflavin, potassium as well as vitamins C and B and is therefore a good health drink. For this work she had to follow a tough routine. It is best to drink Neera before sunrise. Therefore, she had to go to the laboratory at 3 in the morning and start working! But hard working scientists do not care about time. Her research was encouraged and supported by the Khadi and Village Industries. They also benefited from it a lot.

Kamala also studied some of the health issues of Aarey, a milk supply company started by the Maharashtra government in Mumbai, and made some recommendations for improvement. In addition, wherever there was a need to set up a biochemistry laboratory in



India or to appoint professors in that field, for help, Kamala used to be called. She also gave lectures at various science conferences. Many of her research papers were published and many students received doctorates under her guidance. In short, as a scientist, she made a good career without any leverage as a woman. Her husband Madhavrao supported her fully. But at times, even though she was eligible for the post, she was denied the post of director because she was a woman. Finally in June 1969 she held the position of the director for a few years before retiring. She proved to be a good director. What is remarkable about Kamala is that she continued her work even after her retirement. She then turned her attention to social work and used her professional knowledge for social cause. She became a member of the Consumer Guidance Society of India and gave lectures on food adulteration in many places. Not only that, but she also used her research attitude there. She created a 'test box' to find adulteration at home. So even the remote villagers could use it. Initially, she demonstrated it in many places. In 1996, a book named 'Ahargatha' was published based on her articles on 'Food'. Thus, Kamala continued to work till the age of 87. Her end was what a true scientist would like to have! At a special function in her honor in Delhi on 28 June 1998, while giving a lecture she collapsed. Through her own work Kamala Sohonie set an example that Indian women can balance work and home equally well!

Bibha Choudhuri

A Hidden Star...

(1913 – 1991)

Bibha herself had told in an interview in England that there were as many women physicists in England and India together as you could count on the fingers of one hand! Like Anandibai Joshee, Kadambini Ganguli and Kamala Sohonie, Bibha Choudhuri was one of the first few Indian female scientists who had climbed to the top of the ladder of education. While the first two became medical doctors the latter two received doctorate from prestigious Universities in U.K. Kamala Sohonie and Bibha Choudhuri were not given due credits for their achievements even in their own country, but slowly people are trying to correctly make amends to their mistake.

CHAPTER TWENTYFOUR

Calcutta University

Bibha Choudhuri, who was not known to many, was born in 1913, in Calcutta (now Kolkata), just two years later than Kamala Sohonie. Despite receiving good education, doing pioneering work in science, doctorate under the supervision of a Nobel Laureate (Prof. P.M.S. Blackett) and later working at great institutes in India like the Tata Institute of Fundamental Research, Mumbai; Physical Research Laboratory, Ahmedabad etc. Bibha remained unknown to many. She was a hidden star! Dr. Rajinder Singh and Dr. Suprakash C. Roy published in 2018 a biographical book on Bibha Choudhuri through which Bibha's work came to light. In 2021, 'Physics News' published by Indian Physics Association devoted its entire issue on Bibha Choudhuri. Indian National Science Academy also organized a webinar in 2021 on Bibha Chaudhuri's life and science journey.

Bibha Choudhuri's parents were followers of Brahmo Samaj. There was still a social and religious conflict between Brahmos and Sanatani Hindus. Her father came from a Sanatan Hindu family and mother's family had a Brahmo background. They had married against the sentiments of their family making them dissatisfied over a long period of time. Bibha's father Banku Choudhuri and mother Urmila Devi loved each other and got married. He also accepted the Brahmo Samaj as he was convinced with the beliefs of Brahmo Samaj. Brahmo Samaj, founded by Raja Ram Mohan Roy was nearly 100 years old by then and was against the tradition of sati (live burning of the widow with her husband), child marriage and promoted women's education and free participation of women in all their activities. Sanatan Hindu society exactly opposed the thinking of the Brahmo followers. Educated Hindus were either openly following Brahmo traditions or slowly transforming. Banku Choudhuri was himself a medical doctor and decided to break from his parents and their sanatan brahmin family. He was ready to relinquish his inheritance for the sake of his principles!

Dr. Banku Choudhuri worked at Mayo Hospital in Calcutta. He lived happily in Calcutta with his wife Urmila in a rented house on as the present day Prafulla Chandra Road. It was close to Bose Institute. He had five daughters and one son. He and his wife unbiasedly let their children get good education. Bibha had her primary education from Bethune school in Calcutta. It was a reputed school for girls in entire Asia. It was just the dawn of women's education even in the western countries and Bibha was swiftly climbing the ladder of higher education! She obtained B.Sc. degree with Honors in Physics from Scottish College, Calcutta. This too was a very prestigious college of which great persons like Netaji Subhash Chandra Bose and Swami Vivekanand were alumni. In 1934, Bibha took admission

> **Women are terrified of Physics — that is the trouble. It is a tragedy that we have so few women physcists today. In this age science, and physics particularly, is more important than ever, women should study atomic power; if they don't understand how it works, how can they help to decide how it should be used?**
>
> *– Bibha Choudhuri*

in Calcutta University to do M.Sc. in Physics. In India, even in the late seventies of the twentieth century, there used to be a very few girls (4-5) for M.Sc. Physics in a class of about 100 students. Physics and Mathematics were considered to be very tough subjects and most of the girls kept themselves away from it. However, as seen in earlier chapters there are some exceptions. Bibha was the third female student to get M.Sc. degree in Physics from Calcutta University.

After successfully completing her M.Sc. from Calcutta University in 1936, Bibha wished to do research. When she approached Dr. D.M. Bose in Calcutta University, with a request to do research in his group, first he refused saying that he did not have a suitable research problem for a woman. Dr. D.M. Bose had worked with the famous Dr. C.T.R. Wilson (discoverer of Cloud chamber) on constructing the cloud chamber. Bibha was not to give up very easily and was determined to do research on cosmic rays with Dr. D.M. Bose. She persuaded him to include herself in his group for research. When in 1938, Dr. D.M. Bose joined as the Director of the Bose Institute in Calcutta, his whole group including Bibha shifted to the Bose Institute. It was the first Indian institute founded by Sir J.C. Bose for research.

Dr. D.M. Bose was the first Indian Scientist to work on cosmic rays in India. Bibha's most important work with Dr. Bose was on mesons. When nobody knew about the nature and the properties of many fundamental particles they experimentally

proved the existence of mesons in cosmic rays. They showed that a photographic method could be used to detect meson and measure their velocity as well as its mass. For the experiments she travelled in mountainous areas like Darjeeling (~7000 ft), Phari or Pagri Dzong (~14000 ft) and Sandakphu (~12000 ft) riding on the back of the donkeys for transportation. By exposing the photographic plates at different altitudes they could make new findings about meson which gave them four research publications in one of the most respectable science journal 'Nature'. Even with the low quality emulsion photography plates they could make a major contribution to the study of meson. The tracks observed by her were reported to be not due to electrons, protons or neutrons but due to mesons. They (D.M. Bose and Bibha) concluded from their experiments that the mass of meson was approximately 160 times that of electron mass.

Unfortunately Bibha could not get better quality emulsion photographic plates due to the outbreak of World War II. Even the pioneer of photographic emulsion technique for study of cosmic rays Mariette Blau from Vienna, Austria had to stop her work. Mariette was continuously working since 1920s and 1930s on the development of photographic emulsion plates. Although it was known since 1911 that alpha particles produced the tracks in the photographic plates, it was Mariette who indeed developed the use of photographic emulsion method for cosmic rays studies. Her work turned out to be most useful in studies related to cosmic rays, elementary particles and Nuclear physics. However, she suffered in her career due to gender bias as well as racial discrimination. Mariette was of jewish origin and had to flee from Austria leaving her laboratory. She never got the Nobel Prize, though she was nominated several times! Later in 1947, C.F.

Bibha Choudhuri (left) and Dr Sukumar Biswas (right) at the International Conference in Pisa, Italy (1955) (From the book "Cosmic Quests" by S. Biswas; Credit: Noopur Biswas)

Powell using emulsion photographic plates, better than those available to Bibha, observed these tracks and proved the existence of pions decaying into muons, bagging the 1950 Nobel Prize in Physics. He too acknowledged in a book published by him that D.M. Bose and Bibha Choudhuri had correctly observed the mesons earlier and he was aware of their work. He further said that the method used by Bose and Choudhuri to determine the mass of the meson was correct and even the mass of meson was close to what he had found with his improved emulsion photographic plates. Was it then Bibha and her supervisor (also Mariette Blau) missed (or ignored?) the Nobel Prize which they deserved?

Bibha left Bose institute and went to U.K. in 1945 for doing Ph.D. Her father sold part of his inherited property for supporting her stay in Manchester U.K. She worked on cosmic showers under the supervision of Prof. P.M.S. Blackett who got the Nobel Prize for his work on cosmic rays in 1947. As women in physics was a very rare thing in those days, a local newspaper reporter attracted her attention and interviewed her. There she said that it was a pity that there were very few women in physics. Girls are (unnecessarily?) afraid of physics and mathematics. The number of women physicists in England and India could be counted on fingers of one hand. Bibha further said that after compleing her Ph.D. she wished to go back to Calcutta and continue research there.

Bibha submitted her Ph.D. thesis on cosmic rays and it was examined in 1949. However, she was formally awarded the doctorate in 1952. She returned back to India in 1949.

After coming back to India Bibha went to Mumbai to join the newly founded Tata Institute of Fundamental Research (TIFR). She was appointed as a Research Fellow to work in the Experimental Physics Group. As the institute was very new, there were very limited positions of Professor, Reader and Research Fellows. The Professor and Reader's positions were already full and Research Fellow position of TIFR was equivalent to an Assistant Professor's position today. Bibha Choudhuri was the first female researcher at TIFR. Bibha was an important contributor to the TIFR's cosmic rays program. She worked on cosmic rays using scintillation detector coupled with an array of neon flash tubes. Her research was oriented towards the study of interactions of particles at relativistic energies. She had concluded from her work about air showers of cosmic rays that distribution of particle densities obeyed a power law. She also made many more important contributions to research. In fact when an institution is young those who join it initially have to work tirelessly without many publications. Bibha had during her tenure in TIFR only a single research paper with others from her work in TIFR and one

more from her work in Manchester. However, quality is better than quantity! She could have easily got an extension at TIFR but she stayed in TIFR till 1953.

Bibha went as a senior research fellow on a project on cosmic rays in Bengal Engineering College in Calcutta. Her salary there was not higher than what she got in TIFR. So, salary could not have been an attraction. The reason for her accepting a job in Calcutta could be her wish to return to Calcutta as she had expressed it earlier, in her interview to the reporter of The Manchester Herald.

However, shortly in 1956 Bibha went to France as a visiting scientist. She published a paper from the laboratory in France. Then in 1957 she went to the University of Michigan in U.S.A. as a visiting lecturer. Bibha was probably still looking for an opportunity of working on air showers of cosmic rays. She joined in a Council of Science and Industrial Research (CSIR) India project at Kodaikanal in 1959. In 1961, Bibha joined Physical Research Laboratory (PRL), Ahmedabad as a CSIR pool officer. The research project on which she joined was of great scientific interest and close to her heart viz. extensive air showers of cosmic rays. But this time the work was not to be in the mountainous areas as she had done earlier by exposing the photographic emulsion plates but very deep in Kolar mines. The project was known as 'Kolar Gold Field' or KGF for short. She began working on it in 1962. The work was in collaboration with TIFR and the aim was to study high energy (> 150 GeV) muons and also determine the composition of cosmic rays. This was not an easy task and any woman would have been just

A yellow-white dwarf star in the constellation Sextans, located 340 light years away, has been named Bibha, which means "a light beam" and refers to Bibha Choudhuri.

Bibha's exoplanet was christened Santamasa, a Sanskrit word that means "clouded", which refers to the nature of the exoplanet's atmosphere.

taken aback by the thought of going deep inside a mine at a depth of ~700 ft with indigenous lifts or living in an isolated house. Bibha had her own group of students and she used to teach in PRL as well. She was known amongst the students as a very well-prepared teacher and a good supervisor. In 1976, after a long service at PRL, Bibha returned to Calcutta and joined Saha Institute of Nuclear Physics (SINP). She quietly continued her research and publications until her death on 2nd of June 1991.

Bibha was a very shy and simple woman. She carried out research work with conviction and devotion without any expectations. In spite of her magnificent work while in Bose institute and in Manchester during her Ph.D. she remained unnoticed to the scientific community. From some of the early group photos, it appeared that she used to be the only female scientist among the male physicists. However, to work on a tough subject of cosmic rays in which many ideas were unclear she went ahead with courage tracking the cosmic rays. It is said that Bibha never married…she was married to research!

Although Bibha Choudhuri came to light in 2018 through the literature mentioned in the first paragraph, Govt. of India has now acknowledged her contribution to Indian science. International Astronomical Society in 2019 gave the name 'Bibha' to the star H. 86081. People doing good work come in the limelight one day or the other!

Asima Chatterjee

FIRST FEMALE PADMA BHUSHAN AWARDEE SCIENTIST...

(1917 – 2006)

At a time when women could not get higher education in India, in 1944, Asima Chatterjee, who came from a moderate background, was awarded the highest degree of the University of Calcutta. She graduated with a degree in science. After that, Asima never turned back. On the basis of her intelligence, consistency and hard work, she slowly climbed the ladder of success and honor. She received the Bhatnagar Prize which is the most important post independence award given to eminent scientists below the age of 45. It is the highest award for the young Indian scientists. The prestigious Padma Bhushan was awarded to Asima for her excellent scientific contributions by Government of India.

CHAPTER TWENTYFIVE

The image from the collection of Indian Academy of Sciences shows Prof. Asima Chatterjee seated at the Padma Bhusan Award felicitation ceremony at the University of Calcutta, 1975.

(Credit: Google Arts & Culture)

Asima Chatterjee is an inspiration for women scientists in India! She was born on September 23, 1917 in Calcutta in a middle-class family named Mukherjee. Her father Dr. Indra Mukherjee was in the medical profession and was very fond of Botany. Maybe the same love trickled in Asima. The city of Calcutta was quite advanced. The University of Calcutta was established there in 1857 and students from Lahore to Rangoon and Ceylon used to come there for education. Kadambini Ganguly and Chandramukhi Basu, who graduated from there in 1882, became the first women graduates in India. Being a gifted student since she was in school, Asima did not face any difficulty in getting admission in Calcutta University. In 1936 Asima graduated from the reputed Scottish Church college and in 1938 received M.A. in Organic Chemistry from the University of Calcutta. She also won the university silver medal.

In 1940, Asima started working at Lady Brabourne College, where she also started a chemistry department. She began working as the head of that department. In fact, she was highly educated for an Indian woman and her love for research could not let Asima sit doing mundane routine jobs. While working, she started research at the University of Calcutta under the guidance of Prof. P.K. Bose. At that time there were not many scholarships available for research. So almost all the researchers used to do research while working in a college. It was possible only for the rich students to do research without a job. The only option available to the middle-class Asima was to do research while doing a job. Of course, only a person with a strong desire for research can do this. After working strenuously, in 1944, she was awarded the D.Sc. (Doctor of Science) the highest degree in the university. She became the first female scientist to get D.Sc. degree of Calcutta University. She was quite ahead of her times and thus was the 'first woman' in India to earn many achievements to her credit!

Soon after getting D.Sc., Asima was promoted to the post of 'Honorary Lecturer' in the Department of Chemistry, University of Calcutta. It was very important for Asima to be connected to the university for research. Therefore, it was very useful for Asima to have the position of a lecturer in the university.

Asima got married in 1945 to Dr. Baradananda Chatterjee who himself was a famous physical chemist and D.Sc. He became a professor and Vice Principal of Bengal Engineering College, Howrah.

At that time the laboratory facilities required for research were not very up-to-date in Calcutta University. She therefore thought of looking for an opportunity abroad where she could learn new techniques and gain more knowledge which she could use back home. So, she corresponded with scientists in foreign countries

and began to see if she could get a chance to work with them. In 1947 she got the opportunity in the United States to work with Prof. L.M. Parks at the University of Wisconsin. There she did research on natural glycosides. Glycoside is a component of many herbal medicines. Thereafter from 1948 to 1949 Asima worked at the California Institute of Technology in the United States with Prof. Zykmyster. Asima also went to Zurich, Switzerland. There she worked with Prof. Paul Carr of the University of Zurich on biologically active alkaloids. These ingredients found in plants are also used in medicines.

Asima returned to India in 1950 with a rich experience of studying various components of plants for 3-4 years. Although she worked in other countries, she did not forget her rich Indian biological resources. India also has many plants not found in other countries and those are used in a traditional way with experience or practice. But it is important to study or investigate the native medicines using modern techniques. Understanding this, as soon as she arrived she found alkaloids in Indian plants and began work on cumarin. Calcutta University did not have the laboratory facilities like abroad. The university could not provide adequate funding. It was also difficult to get enough students for the research. It was not even possible to give scholarships to the students. The students though interested in doing research could work part-time somewhere and devote a few hours to research. Asima had to spend some money from her meager salary in the laboratory for research. Indeed, that period was not conducive to research. The society was hardly aware of what it means to do research and what are its requirements. Doing research was considered a kind of 'luxury'. Researching and getting a name was not an easy task. However, Asima's indescribable enthusiasm for her own research and in-depth knowledge of the subject, attracted many students who were eager to work with her. That is why it is commendable that 59 of her students received the doctorate of Calcutta University! It is also laudable that Asima was given an opportunity by the university only on the basis of her merits without discriminating between men and women. The period 1950-60 was a time of confusion all over the world as to whether or not to give women the opportunity to do research in a university. In such a situation it is very admirable that Calcutta University appointed Asima as a 'Reader (now Associate Professor)'in the Department of Chemistry in1954. In the past, Lecturers (Assistant Professor), Readers (Associate Professor) and Professors (Professors) in the university were categorized according to their merit and dignity. Therefore, it was definitely an honor to get the position of 'Reader' in a university.

With the Reader's position at the university, Asima no longer needed to rush to both college and university, and was able to devote more time to focus on research. Recognition of her work automatically began to come. In 1960, she was elected a Fellow of the Indian National Science Academy (INSA), Delhi. Indian National Science Academy (INSA), National Academy of Sciences India (NASI) and Indian Academy of Sciences (IASc) are the three science academies in India. It is considered to be a great honor to have a fellowship or membership of these academies because only those who carry out exceptional advanced research are able to get it. Asima became one of the most respected research scientists in India. In 1961, Asima received the most prestigious Shanti Swaroop Bhatnagar Prize. This prize is given every year to an Indian researcher less than 45-years of age for outstanding research carried out in the previous 5 years in the basic or applied sciences in India (chemistry, physics, mathematics, biology, environmental science, engineering and medicine). Only one or a maximum of two scientists receive this award each year in each subject. Asima became the first woman scientist to receive this prize. The Shanti Swaroop Bhatnagar Prize is instituted by the 'Council of Scientific and Industrial Research (CSIR)' and given since 1958 in the honor of its first director and great chemist Dr. Shanti Swaroop Bhatnagar.

Calcutta University had taken an appropriate cognizance of Asima's increasing recognitions. As a result, only within eight years of her appointment, she was promoted to the prestigious Khaira Professor of Chemistry at the University of Calcutta. This was the first time in the history of Indian universities that a woman was appointed to such an honorable position! Asima held this post till 1982. By doing very commendable work, she raised a challenge for those who came after her. In 1972, under the guidance of Asima, the University Grants Board (UGC) started a 'Special Grants Program' in the Department of Chemistry, University of Calcutta. Later, in 1985, it was renamed as Center of Advanced Studies on Natural Products.

Prof. Asima Chatterjee, the first woman to be elected General President of the Indian Science Congress Association (ISCA) delivering the Presidential Address at the 62nd Session of ISCA in 1975. Prime Minister of India Mrs. Indira Gandhi looks on.

Google honoured Prof. Asima Chatterjee by publishing a doodle to mark the 100th birthday of the great scientist.

Similarly, a Regional Center for Research on Indian Medicinal Plants for Ayurvedic Treatment and its adjoining Hospital were set up at the Salt Lake City, Calcutta, with the help of a joint grant from CSIR, Central and the State Government (W. Bengal). Asima also remained the honorary chief coordinator till the end of her life. She developed several drugs and obtained the patents for those. Many commercial pharmaceutical companies brought these drugs in the market. She had developed medicines for epilepsy and malaria, 'AYUSH-56' and many other important medicines. She published more than 400 research papers in national and international journals.

Between 1973 and 1977, CSIR entrusted her with the responsibility to collect information on 'Indian Medicinal Plants'. She carried out this task meticulously and edited six volumes of information on 700 plants and published them.

In 1974, Asima received Sir P.C. Ray award. In 1975, she was showered with many awards and honors. She was awarded Padma Bhushan, the third highest civilian honor of the Government of India. In the same year, she was elected General President of the Indian Science Congress Association. The General Assembly of the Indian Science Congress Association is held every year in India. Thousands of scientists from India and foreign delegates participate in the conference and share their latest research with other scientists. The conference is inaugurated and addressed by the Prime Minister of India. This is a great opportunity for students to meet several scientists. In 1975, Asima was chosen 'Woman of the Year', by the Bengal Chambers of Commerce. In 1979, Prof. P.K. Bose Award was given to her. In 1982, Asima was awarded Sir C.V. Raman award of Hari Om Trust. Despite receiving so many honors and awards, she never felt proud or perturbed due to them in her research. Asima did not compromise in her work. She always believed that the work should be of high standard and one should always devote to complete the work. Asima passed away on November 23, 2006 at the age of 89. But until her end she went to the laboratory to monitor the progress of the work. Even though Asima is not with us today, she has set a benchmark of how much scientific work or research a woman can do in a single birth. On September 23, 2017, Google honored her 100th birthday with a doodle!

Rosalind Franklin

SCULPTOR OF THE INVENTION OF DNA ...

(1920 – 1958)

In the early 20th century, many universities opened their doors to women. They started getting suitable jobs also. But the patriarchal culture was still prevalent. Rosalind Franklin is one of the few female scientists who worked hard at such a time paving the path for Nobel Prize winning research but unfortunately she herself did not win the Nobel Prize. Rosalind Franklin had laid the foundation of research that was crucial to understand the structure of DNA.

CHAPTER TWENTYSIX

Birkbeck College, London
(Credit: https://www.chuarchivestories.ukstoriesrosalind-franklin-and-her-work-on-virus-structures)

Rosalind Franklin was born on July 25, 1920 in London, England. Her parents were rich Jews. Her father's desire to become a scientist remained unfulfilled as his education was cut halfway during the First World War. Rosalind fulfilled his desire. From an early age, Rosalind was a sharp intellectual and an independent thinker. At the age of 15, she decided to become a scientist. Very few school girls were able to learn mathematics, physics and chemistry. She learned and liked these subjects at St. Paul's Girls' School in London. She was also fluent in Latin, German and French. She could speak French very easily. It came in handy when she went on to do research in France. Apart from that, when she was in school, she was also ahead in sports. Her favorite sports were both cricket and hockey. Only in music, however, she was not good. The music teacher once called her mother to the school to enquire whether Rosalind could hear less or had a sore throat! Apart from that, she used to stand first every year in the class. In 1938, she got highest marks in 6 subjects and also got first rank in the matriculation examination. She received a scholarship of 30 pounds per year for 3 years for university education and 5 pounds from her grandfather. But her father advised her to donate the scholarship amount to the children of Jew refugees. Many refugees used to come to England during the World War.

Rosalind's schooling and her school performance were excellent, so in 1938 she easily got admission to Newnham College, Cambridge. She graduated in 1941 and was admitted to Cambridge University to work in chemistry. But she did not like the way her mentor Ronald George Wreyford Norrish was uninterested in the work. Around the same time in 1942 she was offered a research job at the British Coal Utilization Association. So, in just one year, Rosalind left Cambridge University and began research on coal at the British Coal Utilization Association. Since it was a new laboratory, there was no strict discipline. In spite of having lots of freedom at work she was constantly engrossed in her research. Her independent intellect thus gained a nurturing environment. There she wanted to research why water and air get filtered by certain types of coal and why through some types they do not get filtered. She received her doctorate in 1945. By 1947, she had published some research papers on the structure of coal.

Her father used to think that like research, Rosalind should also pay attention to religion. He thought that she neglected the religion. And it really was! She did not believe in religion at all. It was not that she spoke or acted against religion, but she was basically an atheist and was adamant about her views!

In 1947, Rosalind received a scholarship to conduct research in Paris. It was there that Jacques Merring introduced her to the subject of X-ray diffraction.

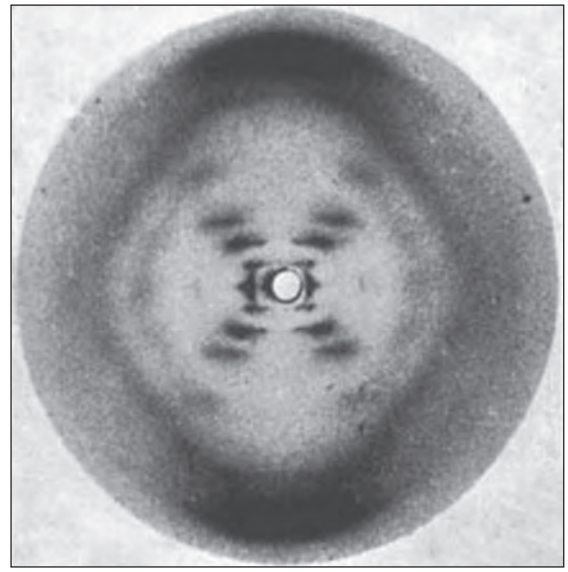
> **You look at science (or at least talk of it) as some sort of demoralising invention of man, something apart from real life, and which must be cautiously guarded and kept separate from everyday existence. But science and everyday life cannot and should not be separated. Science. for me, gives a partial explanation for life. In so far as it goes, it is based on fact, experience and experiment.**
>
> *– Rosalind Franklin*

She found it very useful for DNA research and for other research works. Three years later, in 1951, Rosalind returned to London. She loved living in France, the people there, their manners and the way they ate, and drank.

She received a research scholarship for 3 years at King's College London. Her first job there was to turn on the X-ray machine and make some necessary improvements. Then she had to work on DNA. DNA or deoxyribonucleic acid is a hereditary factor in the cells of all human and animal species. Scientists did not know exactly it's structure or what atoms were there in it and where they were. Therefore, it was a very important subject of research in Rosalind's time. When Rosalind started the work on DNA, Morris Wilkins, a scientist working on DNA, was on vacation. When he returned, he got the impression that Rosalind Franklin would be his assistant! But that was not to be. Rosalind was a very independent and brilliant scientist! Wilkins was upset when he noticed it. Their resentment was so great that forget about working together, their personal relationships also got strained.

When the X-ray machine began to work smoothly, Rosalind started work on DNA. With a student named Raymond Gosling, she first developed two types of DNA crystals with threads. One of them had more water than the other. She took X-rays of the two crystals and took diffraction photographs. By studying them she learned about the basic dimensions of DNA threads as well as their helical nature. She was beginning to have an idea of the (helical) structure of DNA. She also guessed that a phosphate molecule might be attached to DNA thread from outside. But before all of her research was officially published, Maurice Wilkins did not follow the expected ethics of research, and her work was shared without her knowledge with James Watson and Francis Crick at the Cavendish Laboratory in

Cambridge. James Watson, Francis Crick and Maurice Wilkins later won Nobel Prize of 1962, for their work on DNA! She also showed much of her work in a speech at King's College. Watson attended that speech but he did not really understand the speech. Rosalind's work was also featured in the annual report of King's College, which was secretly shown by Max Peruz, a member of the Governing Committee, to Watson and Crick. In fact, it was wrong to give such information. It is said that Watson and Crick got the idea of DNA structure using the X-ray diffraction photographs obtained by Rosalind. In their research article in the journal 'Nature' which revealed the structure of DNA they avoided referring to Rosalind's work. Maurice Wilkins also was working on DNA. But the three never gave her due credit for her work.



The famous x-ray diffraction image of DNA captured by Rosalind Franklin in 1951

Tired of the atmosphere at King's College, Rosalind said goodbye to it, and even to DNA related research. She took a job at Birkbeck College, London where she formed a new research group. Her group was soon regarded as one of the best in the world for research on the molecular structure of viruses using X-rays. She and her research team had made very significant contributions to understand the role of tobacco mosaic virus and some of its acids in the reproduction of pathogens, the role of genetic information in the transmission of proteins and nucleic acids, the role of polio parasites by doing basic work on these very important topics. Rosalind may not have won the Nobel Prize, but credit for her founding research on DNA definitely goes to her. Her diffraction photographs are considered to be some of the best photographs of the time. Watson, Crick, and Wilkins were instrumental in revealing the structure of DNA. If she would have lived until 1962, she might have won the Nobel Prize! Watson, Crick and Wilkins got Nobel Prize four years later, in 1962, after her death (she died of cancer on April 16, 1958).

Watson and Crick later wrote their popular book 'Double Helix' on DNA. They did not even acknowledge Rosalind Franklin's contribution, which indeed

> **My method of thought and reasoning is influenced by a scientific training—if that were not so my training will have been a waste and a failure.**
>
> *– Rosalind Franklin*

was huge, and tried to hide it. Instead they wrote some hilarious texts about her personality. Many scientists, even some very famous scientists did not like it at all. They openly criticized Watson and Crick for it. Rosalind, Wilkins, Watson and Crick never worked together. Rosalind was therefore not morally bound to show them her research, even when it was incomplete. No scientist does that! However, since they already knew Rosalind's work, because of her work, they got clues about the DNA structure. It was, of course, wrong on their part not to mention or give reference of her important work, while publishing a research paper. That is why research scientists, working on DNA equally honor Wilkins, Watson and Crick and Rosalind Franklin.

Despite being stricken with cancer, Rosalind was working to the end, guiding the students. She published seven papers with her colleagues in 1956 and six in 1957. She disposed of her property in a will among her colleagues, relatives and nurses. She died on April 16, 1958.

In many places after her death, attempts were made to pay homage to her in different ways. In 1982, 'Iota Sigma Pi' an American women's advocacy organization, awarded her a 'National Honorary Membership'. In 1992, British Heritage affixed a blue plaque of her name on the building in which she lived until her death. In 1933, King's College renamed one of its buildings in Hampstead as Rosalind Franklin Hall. In 1993, outside the King's College building in London, Franklin was shown along with a few other scientists on the blue board. Newnham College set up a student dormitory in 1995 and named it the Rosalind Franklin Building. An asteroid discovered in 1997 was named 'Rose Franklin'. In 2000, King's College renamed another building 'Franklin-Wilkins'. In addition, many buildings or sections are named after Rosalind Franklin in several countries. Most recently, in 2017, DSM company launched in the Delft, Netherlands a 'Rosalind Franklin Biotechnology' department. Some plays have been written on her and in some places her story tells what and how science works. In some places the drama is colorful showing her angry and frustrated about not getting the Nobel! Whatever it was, while Rosalind Franklin was alive she was unfairly treated. She had received all the honors, only after her death, when the truth slowly unfolded to the world!

Rosalyn Sussman Yalow

STEADY AND FOCUSED WORK WITH DETERMINATION AND DEDICATION .....

(1921 – 2011)

Without complaining about difficulties and many problems, by doing dedicated research work Rosalyn Sussman Yalow, succeeded doing frontline research and received the Nobel Prize (1977) for the development of radioimmunoassay technique! She was the first woman, born in United States of America, to receive the Nobel Prize. Inspired by the goal of working well in nuclear physics, the important research she contributed to the field of nuclear medicine is still used in diagnostics and therapies.

CHAPTER TWENTYSEVEN

Rosalyn Yalow receives the Nobel Prize in Physiology or Medicine 1977 from King Carl XVI Gustaf of Sweden
(Credit: Nobelprize.org; Photo courtesy: Benjamin Yalow)

Even before Rosalyn Sussman Yalow's birth, from 1920, women in the United States began to enjoy all the rights that men had. But only on paper! The mentality of the people had not changed. Problems do not go away unless some ideas are rooted in the society, no matter what the laws are. So Rosalyn had to undergo lot of hardships in life. Rosalyn's determination was so strong since her childhood that nothing could stop her from doing what she had decided to do.

Rosalyn was born on July 19, 1921, in Bronx, north of New York. Her mother's name was Clara Zipper and her father's name was Simon Sussman. Her brother Alexander was 6 years older than her. They were Jewish immigrants who settled in the United States. The financial situation of the house was not good. With the exception of 3-4 years, Rosalyn had spent her entire life in New York. Both her parents were not able to get even primary school education due to financial constraints. But they were determined to complete the college education of both their children. Dreams of Yalow family were very limited. They wanted the daughter to learn and become a teacher in a school. Of course, this was not surprising, because there were no examples of women going to higher positions than that! But something very good was written for Rosalyn's future!

As a result of her parents' thinking and teaching, Rosalyn began to read before she went to kindergarten. Unable to afford books, she and her brother used to bring home books from the public library for reading. If the parents are not educated then the siblings or the teachers have more influence on children, as their world is very small. Rosalyn loved mathematics until she was in the 7th grade. But at Walton High School, due to her teacher Mr. Mondzac who taught chemistry, she began to like chemistry. At New York City College, Professor Herbert N. Otis and Duane Roller inculcated deep interest in her towards nuclear physics. At the time it seemed that every major experiment in nuclear physics was a new discovery and a new Nobel Prize. It is therefore no surprise that young people were interested in science and fascinated by nuclear physics. Around the same time Rosalyn read the biography written by the daughter of Marie Curie, the Nobel Laureate, on her mother's life. She also listened to a lecture by Enrico Fermi at Columbia University. And done! Rosalyn no longer wanted to do anything else than study atomic physics and make a career in physics. After deciding this, she began to take steps in that direction. Despite her parents' opinion, she aimed to first get her M.Sc. in physics and then do Ph.D. In a way her parents were also right in their view as what could she do beyond becoming a school teacher by learning more?

> **The only difference between men and women in science is that the woman have the babies. This makes it more difficult for women in science, but... it is merely another challenge to be overcome.**
>
> *– Rosalyn Sussman Yalow*

Rosalyn was encouraged by her professors to pursue further education. But as she tried to move forward, she faced various challenges. However she knew that she had to succeed! Just like Arjuna in *Mahabharata*– a famous Indian epic, before shooting an arrow towards the bird only the bird's eye was in the view of Arjuna and nothing else. Rosalyn had to do research only in nuclear physics! But the most important question was how to get money for further education. With the help of a professor in her college, she got the secretarial job with Prof. Rudolf Schweinheimer at the Columbia University. She also took the stenography training required for the secretarial job and started working for him. She did not want to lose an opportunity of working at the university. If she would get a chance, it was here only! Moreover, Dr. Rudolf Schweinheimer was a physician and surgeon. Fermi's lecture suggested that nuclear physics could be used not only for nuclear war but also for the diagnosis and treatment of patients using radioisotopes. This statement had made a deep impact on her. So, it was a big deal for her to get a job with a famous doctor professor. This indeed was a great opportunity. But within a few days, she got an even better chance. She had applied for an assistant's position to teach physics at the University of Illinois at Urbana-Champaign, and it was approved. While she was working, she could complete her M.Sc. So she decided to leave Columbia University and go to the University of Illinois. When she arrived, she realized that she was the only girl student among 400 students. The dean of the faculty congratulated her and said that after 1917 she was the first girl student to come here.

On her first day at the university, Rosalyn met Aaron Yalow. They were both in the same class and got married in 1944. Their world became very happy. They had a son and a daughter. Although Rosalyn and Aaron were both physicists, their research areas were in different subjects. But Aaron was aware of the ups and downs of her work and was always ready to hear about her work. In her first year of M.Sc., Rosalyn realized that she had a B.Sc. of Hunter College and the physics course there was far behind the course at Illinois. So she started to attend some B.Sc. classes. She also had to as an assistant, teach physics to new

entrants. Even there, when she started teaching for the first time, she faced difficulties. But she tried to learn by sitting in the classrooms of those who were known as good teachers. By working hard like this, overcoming her shortcomings Rosalyn was trying to go ahead. When she got first class in the theory course in the first examination, the head of her department said, 'This proves that women are not capable of working in a laboratory!' However, Rosalyn was not intimidated by the criticism. Not only sound education but dedication also is required. Rosalyn graduated in 1942 from the University of Illinois with M.Sc. in Atomic Physics.

The next stage was to do Ph.D. Rosalyn was accustomed to the atmosphere and her confidence also had grown at the University of Illinois! She got her Ph.D. in 1945. Her supervisor for Ph.D. was Prof. Morris Goldhauber, who later became the director of the Brookhaven National Laboratory. The Goldhauber couple helped her a lot while she was working in the University. Prof. Goldhauber's wife had a doctorate in physics and knew about the difficulties faced by women as she herself could not get a job at the university because of her gender.

After receiving a doctorate, Rosalyn got a job as an assistant engineer at the Federal Telecommunication Laboratory in New York. Her husband's Ph.D. work

Rosalyn Yalow, who developed radioimmunoassay, a method for measuring concentrations of substances in the blood. (Credit: Nobelprize.org; Photo US Information Agency)

> **The failure of women to have reached positions of leadership has been due in large part to social and professional discrimination.**
>
> *– Rosalyn Sussman Yalow*

was delayed due to World War II, so she went to New York alone. Even there, she was the only female engineer in the organization. She then got a teaching job for adults who wanted to become engineers, at her own Hunter College. This work was not related to her Ph.D. work but she had job urgency! But soon her husband got Ph.D. He began teaching medical physics at Montefiore Hospital in the Bronx, New York. Through his acquaintance, she got a part-time job as a radiotherapist consultant at the Bronx Veterans Administration (VA) Hospital. So for 4-5 years, she worked full time at Hunter College and part time at VA! While in VA, with the help of Dr. Rosevit and some other doctors, she built a laboratory where radioisotopes could be used to diagnose patients. In those days such laboratories did not exist elsewhere that made use of radioisotopes in the medical field. It was a completely new idea. Here Rosalyn's Ph.D. in Atomic Physics and experience was useful. Handling radioisotopes is a very risky job, but she knew how to do this work. She along with Dr. Rosevit, published six research papers which were very well received by the scientific community.

When Rosalyn got a full-time job at VA in 1950, she gladly accepted it and quit teaching at Hunter College. Few days after it, she met Dr. Solomon A. Berson, at VA. Being a doctor he was going to be very useful in her work. He also happily joined her research group. Their work matched so well that for the next 22 years, till his heart failure they worked together. Shortly before his death, Dr. Berson had taken over the presidency of the Mount Sinai School of Medicine without listening to Rosalyn. But their work in the VA, which guided the use of radioisotopes in the medical field, still remained very useful to mankind today.

Dr. Berson and Rosalyn stopped working with others after 1950 and started in a new direction. First, radioisotopes were used to diagnose how much blood is in the body, to treat thyroid, to diagnose iodine in the body, and to diagnose the kinetics of iodine metabolism. Using radioisotopes, they researched globin (a protein involved in the production of hemoglobin) and distribution of vaccines in the body. The most crucial thing was to do all this in a living body (*in vivo*). The next step was to use radioisotopes to determine hormones in the living body. From their research, they found that patients who were given animal insulin soon developed antibodies in their bodies. By 1959 they developed the important method of

> **We still live in a world in which a significant fraction of people, including women, believe that a woman belongs and wants to belong exclusively in the home.**
>
> *– Rosalyn Sussman Yalow*

'Radioimmunoassay (RIA)'. This method not only spread in other branches of VA in the country but soon spread to other countries also. So, VA became known as a leading hospital in the world. The management board of VA also was excellent. They not only permitted Rosalyn and Berson to set up state-of-the-art laboratories, but also allowed their research team to grow.

Rosalyn also bought a house in Bronx, New York. After seeing all this, Rosalyn's mother told Rosalyn that it was good that she had done what she believed in. Rosalyn was very happy at home and in the laboratory at VA. Rosalyn and Berson regularly published their work in leading science journals. As a result, they received invitations to lectures and conferences in many places. Rosalyn did not like leaving her home and children. Therefore, Dr. Berson was getting projected. Rosalyn felt very comfortable in working together and trusted him. He also made frequent visits to Rosalyn's family. So, when he accepted the presidency of the Mount Sinai School of Medicine, she tried hard to dissuade him. She was of the view that the position was more of a management one and she felt that it would be more stressful for him to work there. Even so, after he left VA, they still continued to publish together.

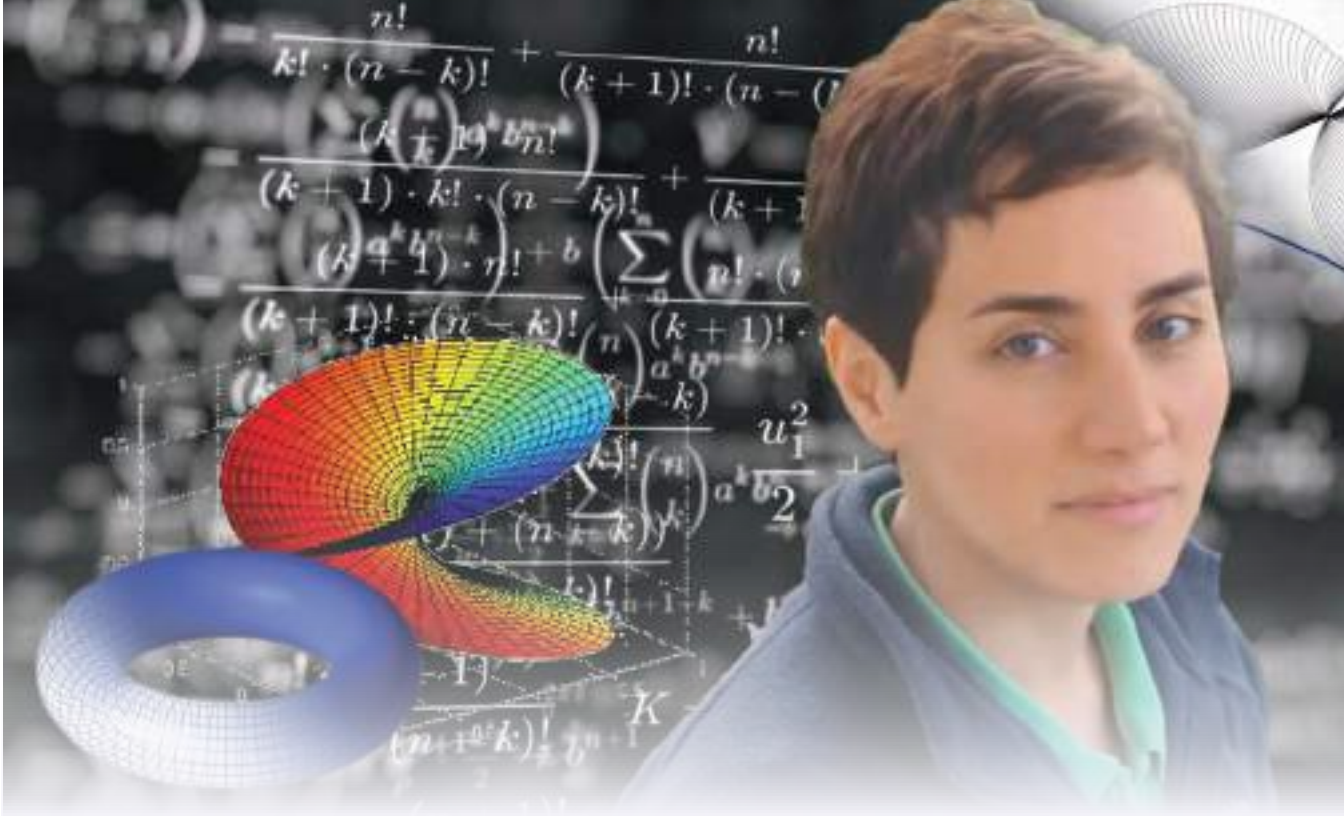
Now Berson and Rosalyn were nominated for the Nobel, and suddenly Dr. Berson was struck by time. He died suddenly of a severe heart attack before getting any treatment. Everyone in VA and the medical field were shocked. It was a long-term association for Rosalyn. It was the trauma of losing a close friend and a great professional colleague. Not only that, their nomination for the Nobel Prize was also dropped! Nobel Prize is awarded only to the living persons and even if one of the two is dead, nomination is dropped. In this manner Rosalyn's dreams were shattered.

Since Rosalyn had not gone to many meetings and science conferences, people began to speak of his intelligence and talking that it was Berson's brain behind Rosalyn and Berson's work! Dr. Berson's personality was impressive and his friend circle was very large. In addition to research, he also loved music. In contrast, Rosalyn's world was very small. She had confined herself to the house and the laboratory. She was not very outgoing. But Rosalyn was very focused at her work. She now began to come out of the emptiness caused by Berson's demise.

Although she was saddened in her heart by the criticism from people, she was aware that she did not have a medical degree and her field of research was not related to medical science. So she once thought that she should try to get M.D., a medical degree. But doing so would mean reassuring people that Berson was all behind their research work, and it would be like ruining her 20 years of hard work. She and Dr. Berson knew that she had an equal share in their work. But to tell people that, Dr. Berson should have been alive!

Rosalyn was not a person to give up her hopes. In 1974, two years after Berson's death, she gave Berson's name to her laboratory in VA. Therefore, through the address on all her research papers, Dr. Berson became immortal. She now started recruiting well-trained post doctorates from home and abroad. Her group worked on many other hormones and published 60 papers in the next 4 years, without Berson. Her children were grown up by then and she could go to meetings. She started getting recognition independently. So she again thought that she would win the Nobel Prize! Every year on the day the Nobel Prize was announced, she would nicely dress up and have a cold champagne ready! If someone says 'good news', she should be ready! And that news came in 1977. The night before, she couldn't sleep and left for the lab at 6.30-7.00 in the morning. Her cherished dream of doing something of the highest quality in nuclear science was proved. It was a confluence of high aim, focus, perseverance and hard work.

Along with the Nobel Prize, many honors came to Rosalyn Yalow from home and abroad. Rosalyn was the first woman scientist who was born is America and won the Nobel Prize. She was the second American woman scientist after Gertie Corey to win the Nobel Prize in Medicine all over the world. She became the sixth female scientist in science to win the Nobel. In 1979, she was selected for the American Academy of Arts and Sciences. In 1988, she was awarded the National Medal for Science. Rosalyn received a total of 60 honorary doctorates. Societies of which only M.D. doctors become a member also honored her with honorary membership. A 'Ladies Home Journal' decided to give her the award as 'Brilliant Woman' but she politely declined seeing that it was being given as 'Brilliant Woman' instead of 'Brilliant Scientist'! Seeing the peak of Rosalyn's happiness and success, her second wheel of happiness fell in 1992. After Aaron Yalow's death, her 50 years of happy family life came to an end. Rosalyn also suffered a heart attack in 1993. However, she continued to work at VA until 2002. Afterwards she fell in the house 1-2 times and it became impossible for her to walk. Rosalyn Sussman Yalow died in Bronx, New York on May 30, 2011.



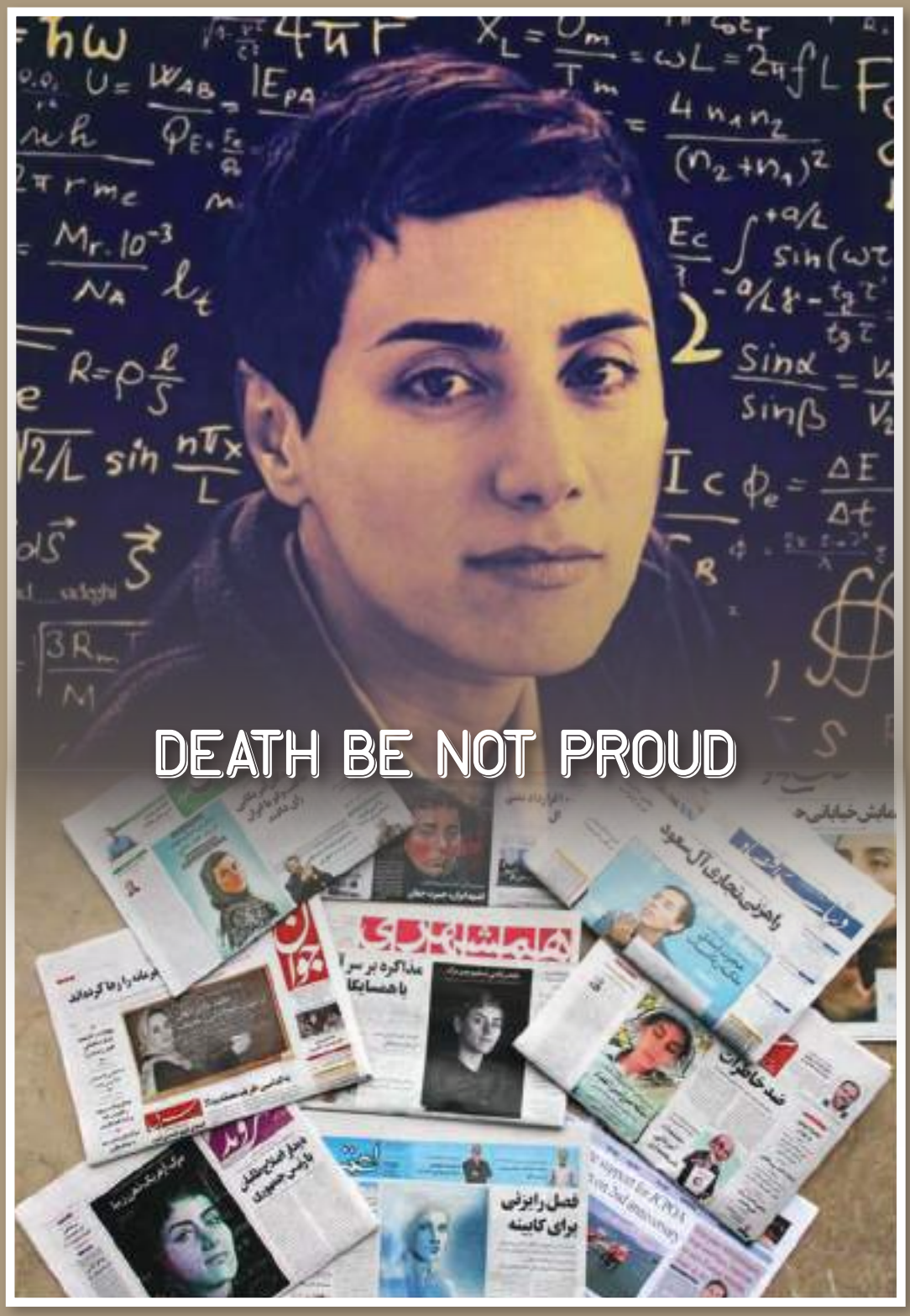
Maryam Mirzakhani

FIRST WOMAN TO WIN 'NOBEL PRIZE' IN MATHEMATICS ...

(1977 – 2017)

Maryam Mirzakhani received the Fields Medal, also known as Nobel Prize in Mathematics. She was the first woman to receive it, and that too an Iranian woman, considered to be very traditional! Maryam Mirzakhani had a very short life. But her contributions to mathematics were so vast that she is known as the 'Queen of Mathematics'.

CHAPTER TWENTYEIGHT



Front pages of Iranian newspapers bearing portraits of the mathematician Maryam Mirzakhani, who died of cancer on 14th July 2017 barely at the age of 40.

It is not important how long a person's life is but what is important, are the achievements made in life. This exactly applies to the case of Maryam Mirzakhani. When Iranian women are mentioned, women wearing a thick black veil or at least a black handkerchief (*hijab*) on their heads, a long coat down to the ankles with long sleeves up to the wrists comes to mind. Not just older women but young girls are also no exception. From their attire we think that these women must be oppressed by tradition and patriarchal culture. But it would not be right to judge a person's true position or condition by his or her clothes! Today, Iranian women are not short of education or denied any opportunity for education. Many Iranian women are doing well in education and research, and they have the same rights as men.

In 1978 Ayatollah Khomeini was given all political and religious powers in Iran after the overthrow of Shah Mohammad Reza Pahlavi, also known as the 'Islamic Revolution of Iran'. After that, instability was created in Iran for some time, but finally on April 1, 1979 Iran was declared an 'Islamic Republic'. The King of Iran left for the United States with his family. But from 1980 to 1988 there was a long Iran-Iraq War. As a result, the economic situation in Iran was dire. But after 1990, gradually economic stability returned and the country began to somewhat get modernized. The attraction of western culture and education began to grow among the younger generation. The country began to move towards modernization and some of the norms and traditions were lost. This is the situation with women's clothing. Although it is compulsory for women to wear a headscarf or *hijab* to cover their heads and long coat or a full body cover, they can (only in public places they have more restrictions) live more freely now. Girls have the same rights to education as boys.

Born on May 3, 1977, Maryam Mirzakhani considered herself lucky, as the period of instability in Iran ended when she was in school and growing up. She knew that if she was born 10 years earlier, she would never have received proper schooling! Her father Ahmed Mirzakhani was an electrical engineer. Her mother's name was Zahra Mirzakhani. Maryam had two brothers and a sister.

Maryam was educated at the Tehran Farzangan School, part of the National Organization for the Development of Exceptional Talent. It was a school only for intelligent children. It was a girls' school and the girls were highly encouraged to study. In her early years, Maryam loved literature. She loved to read stories and novels and also to read whatever she could find. She dreamed of becoming a great writer. She and one of her schoolmates would go to the shops on the street near the school to buy a lot of books and take them home to read. Maryam's parents

> **I get excited about (math) maybe, just as a challenge. You have to spend some energy and effort to see the beauty of math.**
>
> *– Maryam Mirzakhani*

never opposed her. They just wanted their children to be good at whatever they did. Maryam had an elder brother. He used to tell her about mathematics and science. He once told her how to add numbers 1 to 100. She was attracted to mathematics and became interested in it. In 1994, she got an opportunity to participate in the International Mathematical Olympiad held in Hong Kong. She became the first Iranian student to win a gold medal at the Mathematics Olympiad. She continued to climb the steps of success. The following year, in 1995, she went to Canada to compete in the Olympiad, and for the second time, won the International Mathematical Olympiad gold medal for Iran. This time, she became the first Iranian student to get cent per cent marks in it! By then Maryam realized that her career and her passion was mathematics! The more she focused at mathematics, the more she liked it.

After schooling, Maryam gave national entrance examination for admission to a college. Successfully passing the entrance examination she joined Sharif University

Maryam Mirzakhani (bottom left) and the Iran Math Olympiad team at York University in 1995. She was 18-years-old and won gold with a perfect score of 42.

of Technology in Tehran. Sharif University was and continues to be one of the best universities in Iran for both education and research. In 1999, she was awarded a B.Sc. in Mathematics.

> **The beauty of mathematics only shows itself to more patient followers.**
>
> *– Maryam Mirzakhani*

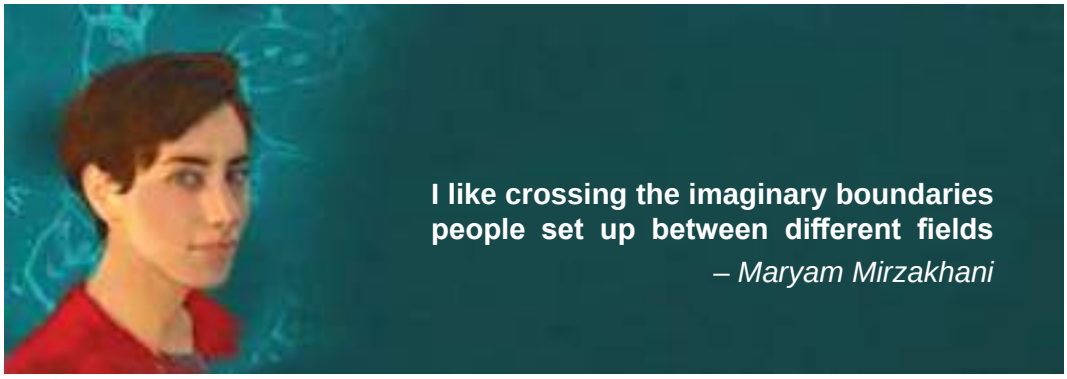
Maryam then straight away went to Harvard University in the United States to get Ph.D. There she realized that she had not learnt many of the subjects, which were taught in the United States to undergraduate and postgraduate students! But without getting frustrated, she unofficially started attending Prof. Kurt McMullen's lectures. Prof. Kurt McMullen was an expert mathematician who had won the Fields Medal in Mathematics. There is really no Nobel Prize in mathematics. But 'Fields Medal' is equally prestigious as the Nobel Prize. Maryam often did not understand McMullen's lectures. But discussions with him were very helpful to her. She began to learn some tough mathematics problems. Prof. McMullen's method of simplifying the subject matter was increasing her knowledge, and the discussions she had with him gave certain direction to her thought process. McMullen saw her intellect, through her questions and was eager to help her.

In 2004 under the guidance of Kurt McMullen, Maryam received Ph.D. degree of Harvard University. The title of her thesis was 'Simple geodesics on hyperbolic surfaces and volume of moduli space of curves'. Her Ph.D. dissertation is considered to be a 'masterpiece'. She had found answers to two, hitherto unanswered mathematics problems. The work on one of them also could have been sufficient to earn her a Ph.D. degree! Her research papers were published in three best journals in mathematics. Her work was praised not only by her mentor but also by many mathematicians from other universities. She had a habit of doing independent research. Her professors liked her attitude of working 'boldly and fearlessly'. Maryam, however, was very simple, straightforward, and polite in her manners.

Maryam began her career in 2004 as a Research Fellow at the Clay Mathematics Institute and as a professor at Princeton University. Then in 2008, she became a professor at Stanford University. Whether Princeton or Stanford, these universities are known as world leaders. Becoming a professor in such a place was not a small deal. Her contributions to mathematics are unmatched like these universities. She showed important directions in mathematics by working on very difficult topics such as Riemann Surfaces, Closed Geodesics on Compact Hyperbolic Surfaces, Teichmuller Dynamics of Modular Space that would make one feel Greek-Latin!

She was awarded the Blumenthal Award in 2009, the Slater Award in 2013 and the Clay Research Award in 2014. On top of all this, in 2014, Maryam Mirzakhani received the Fields Medal, considered to be the Nobel Prize in Mathematics. The Fields Medal has been awarded by the International Mathematical Union since 1936. Every 4 years, it is given to young scientists up to the age of 40 for their most important research in mathematics. This award is given at a time to a maximum of 4 persons. Maryam Mirzakhani received the award in 2014 along with three others in Korea. Maryam was the first Iranian to receive the Fields Medal, and she was also the first female in the history of the Fields Medal. In this way, Maryam fulfilled her parents' wish to become an expert in whatever she did! She received the award for her research in Dynamics and Geometry of Riemann Surfaces and Their Modular Spaces. Jordan Ellensburg, a mathematician, simplifies the subject matter of her award by saying, 'A lot of the research that Maryam has done is research on billiards! It combines dynamics and geometry. But going beyond that, the shape of her table is not permanent but is constantly changing according to certain rules. Besides, this table is a table like many planets in the universe and it is also a revolving table! This is a kind of research to get the Fields Medal .....'. One can imagine indeed how complex mathematics problems Maryam was dealing with!

Maryam had a dual citizenship of both United States of America and Iran. As soon as she left Iran, she soon started speaking and writing English fluently, but she wrote her notes only in Persian. She would talk in Persian when she met Iranian citizens. She never gave up her Iranian citizenship. Maryam married a Czech researcher named Jan Vondrák, who used to work in IBM company. They had a daughter named Anhita. The daughter enjoyed her mother's work very much. She used to say that mother's work was like drawing a painting. Taking a large blank piece of paper, she hits the doodle and writes notes all over it!



Credit: www.mu-sigma.com

In 2013, Maryam was diagnosed with breast cancer but she was still working. In 2014, she visited Oxford in U.K. where students at the University of Oxford established a society named after her. The French Academy of Sciences honored Maryam Mirzakhani by making her foreign associate in 2015. In the same year she became the fellow of American Philosophical Society. In 2016, she became a member of National Academy of Sciences. In 2017, she became the elected fellow of American Academy of Arts and Sciences. She died in Stanford at the age of 40 on July 14, 2017. Scientists from all over the world, not just Stanford University, were shocked. Iran literally went into a sea of sorrow. Iran's President

Honoured with Fields Medal 2014 (Seoul). Left to right: Martin Hairer (MF), Manjul Bhargava (MF), Park Geun-hye (President of Korea del Sur), Maryam Mirzakhani, Ingrid Daubechies (President of IMU) and Artur Ávila (MF). Fifty-two medallists of the previous years were all men.
(Credit: https://mujeresconciencia.com/2016/02/03/maryam-mirzakhani-dibujar-garabatos-ayuda-a-mantenerse-conectada-al-problema/)

Stamp released in the honour of Maryam Mirzakhani

Hassan Rouhani expressing grief over her death said that Iran and the world had suffered a great loss due to her departure. He also said that she had set a great example for all Iranian women. Iranian newspapers are banned from publishing photos of any woman without *hijab*. But 14/15 July 2017 were very exceptional days. All Iranian newspapers carried a photo of Maryam on the front page, just as she was in the United States, without a *hijab*. Sharif University of Technology announced that it would rename its mathematics department after Maryam Mirzakhani. According to Iranian law, children of women who marry a non-Iranian foreigner do not have Iranian citizenship. But many members of parliament tried to get her daughter an Iranian citizenship! In 2020 a documentary film 'Secrets of the Surface: The Mathematical Vision of Maryam Mirzakhani' was released. An asteroid 321357 was named as Mirzakhani. In this way, though Maryam Mirzakhani had a very short life, she will remain memorable for a long time.

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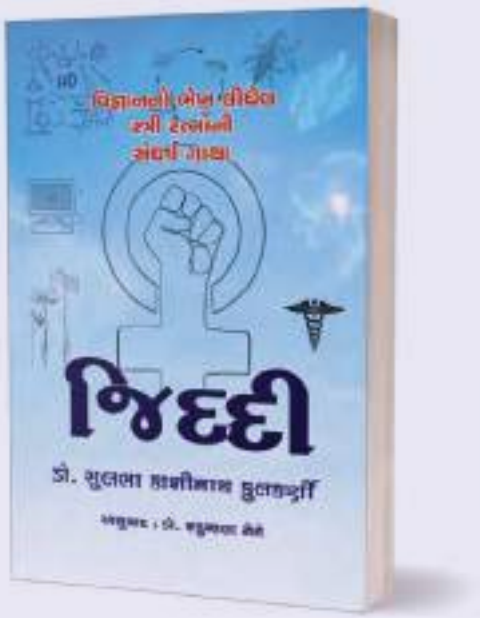

Translated in Gujarati

Jiddi

THE ZEALOUS ONES

The Book

Science equally attracts men and women. However, historically women all over the world were stereotyped to be good daughters, wives and/or mothers. They were supposed to be only caring all the time for home and not to bother themselves with education, forget about going to universities or participate in any 'intelligent' activities of the society. Many men and even women could not understand why some women wanted to get educated! Struggling through such mentality some extraordinary women from different parts of the world found their own ways out. As if gender discrimination was not sufficient, some had to undergo even racial discriminations. Yet, some women overcame societal barriers and bravely contributed significantly to the advancement of physics, chemistry, biology, geology, mathematics and medicine. This book portrays briefly 28 such women from fourth to twenty first century. Their stories can still inspire many struggling students as well as find interesting to the others. Not all great women scientists in all the disciplines could be covered and only those who have passed away are included.

The Author

The author, Prof. Sulabha Kulkarni is presently an INSA, Hon. Scientist at Centre for Materials for Electronics Technology (CMET) Pune, India. Prof. Kulkarni has a long research and teaching career of over 50 years. Before joining CMET, Pune, she has worked at IISER, Pune, Banasthali University Rajasthan (as Pro-Vice Chancellor) and University of Pune. She has over 300 peer-reviewed research journal publications and supervised 40 Ph.D. students. Prof. Kulkarni has also authored four books as well as coauthored three books. Prof. Kulkarni has widely travelled in Germany, France, U.K., Italy, Japan, Korea, China, Taiwan, Singapore and many other countries either for collaborative research or conferences. Prof. Kulkarni is a Fellow of Indian National Science Academy (Delhi) Indian National Academy of Science (Allahabad), Indian Academy of Science (Bengaluru), Maharashtra Academy of Science and Academician of Asia-Pacific Academy of Materials (APAM).

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