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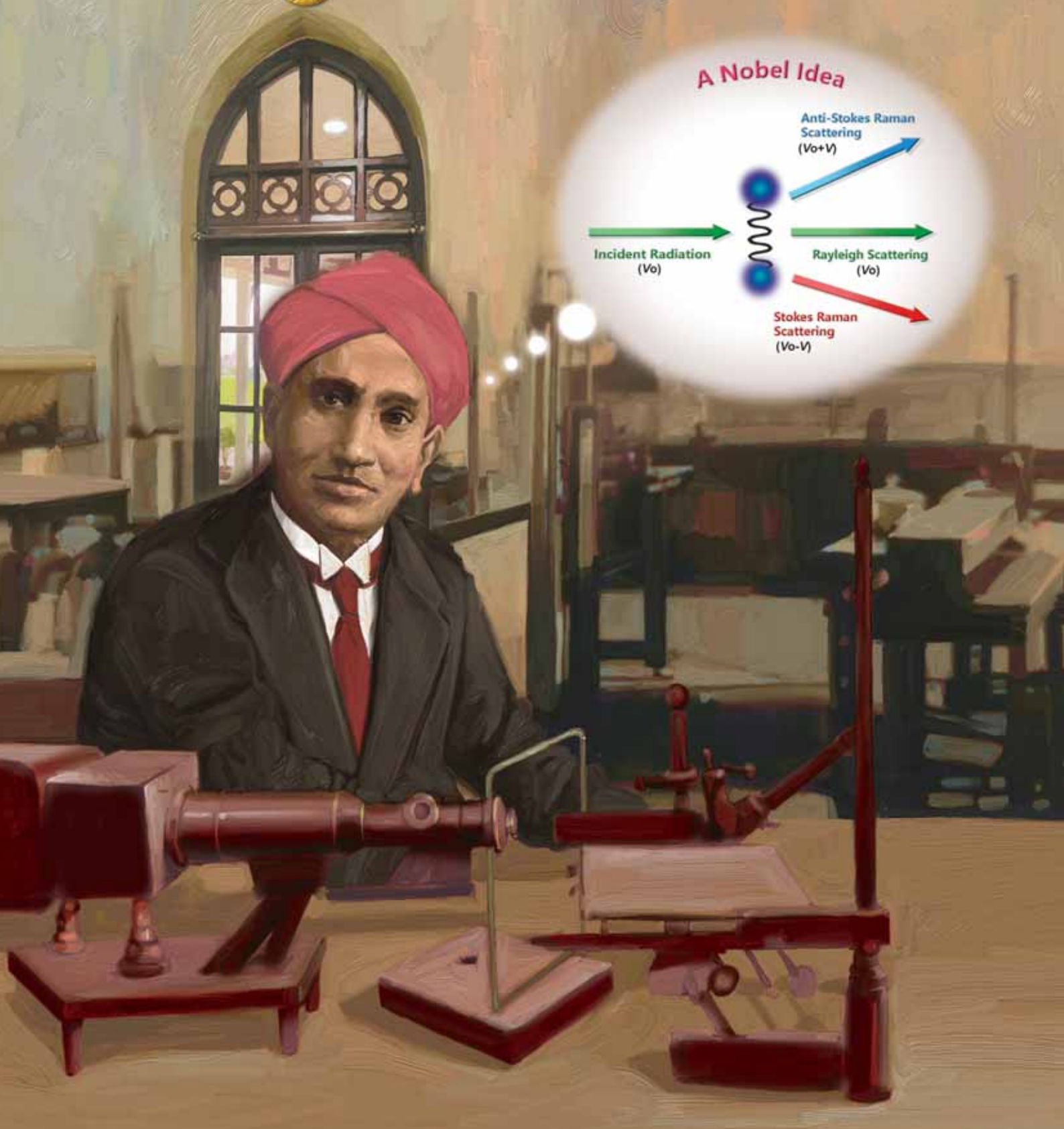
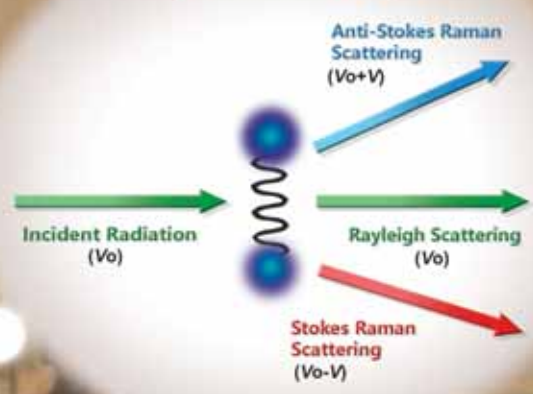
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Azadi Ka
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SIR C.V. RAMAN

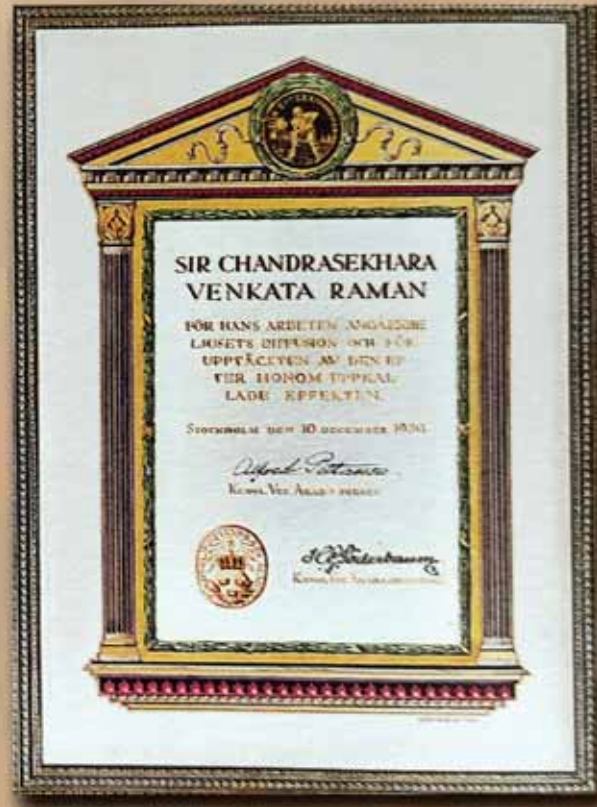
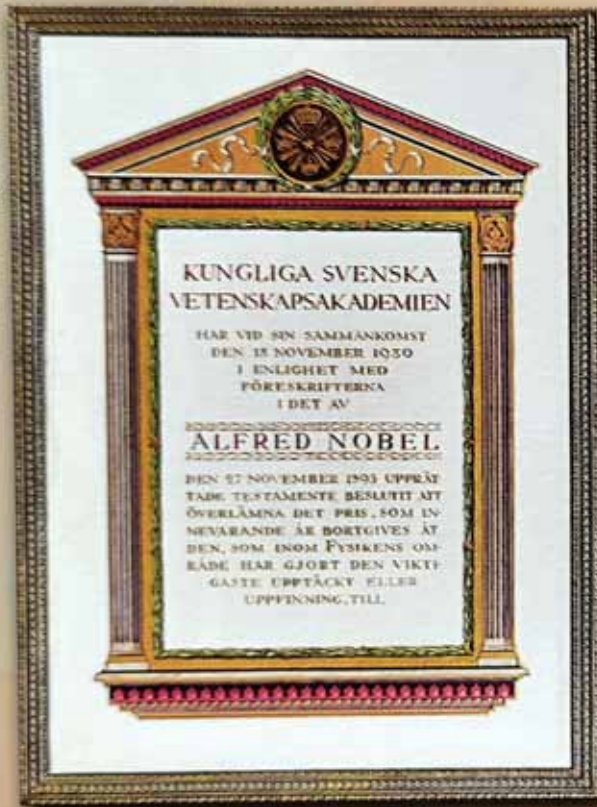
DISCOVERY OF RAMAN EFFECT



A Nobel Idea



RAMAN'S NOBEL CITATION AND MEDAL



SIR C.V. RAMAN

DISC  VERY OF RAMAN EFFECT



DEPARTMENT OF ATOMIC ENERGY

SIR C.V. RAMAN

Discovery of Raman Effect

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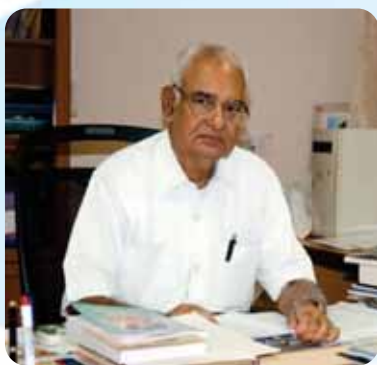
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This picture book is not for sale. The picture book is intended to make readers (particularly the younger students) aware about the scientific contributions of Sir C. V. Raman. Suggestions/Feedback are welcome and can be sent to Dr. R. K. Vatsa by email: rajesh.vatsa@dae.gov.in



Foreword



Sir Chandrasekhara Venkata Raman was, in his time, the best known scientist of India. Exceptionally bright, young Raman, after getting a degree in Physics from the University of Madras, joined the Indian Financial Service securing the first rank in the All-India entrance exam. In 1907 Raman reported for duty in Calcutta, which was then the Capital of India. Raman was forced to take up a bureaucratic job since opportunities for engaging in scientific research did not exist back then. One day by chance, Raman discovered the existence of the Indian Association for the Cultivation of Sciences (IACS) in Calcutta. Thereafter, Raman began to lead a double life, office work during day time and research at night. The research was very productive, and enabled Raman to publish original papers in many scientific journals.

A few years later, Sir Asutosh Mookerjee, then the Vice Chancellor of Calcutta University invited Raman to become a full time Palit Professor in the University. Raman readily accepted the invitation, even though it meant a huge cut in his salary. Raman was now able to devote all his time to physics research and physics teaching.

On February, 28, 1928 Raman made an important discovery now called the Raman Effect. In 1930, Raman was awarded the Nobel Prize for Physics for the discovery of the effect now named after him. That is the reason why 28th February is now celebrated as National Science Day.

Shortly after that, Raman was appointed the Director of the Indian Institute of Science, I. I. Sc., in Bangalore. In 1948, Raman retired from I. I. Sc., and moved to the Raman Research Institute which he had established in anticipation of his retirement, where he focused on research in topics he loved.

Raman loved teaching and his lectures were not only inspirational but also filled with humour. During his long career, Raman trained many students, notable among them being (in the order of seniority), K. R. Ramanathan, K. S. Krishnan, S. Bhagvantam, G. N. Ramachandran, S. Ramaseshan, A. Jayaraman, and L. A. Ramdas.

Raman firmly believed that the quality of the Indian mind was in no way inferior to that of the Western mind, and what Indians lacked was self-confidence. Raman inspired many and thanks to those who came after him, India has now made a quantum leap forward in basic research, atomic energy, and space. Not only that; India is now able to build accelerators, reactors, and launch satellites. There is one area where we need to catch up, and that is high speed computers. I hope India would achieve that goal in the 21st century.

I heartily congratulate the Public Awareness Division of the Department of Atomic Energy for bringing out a book on C.V. Raman, the founding father of modern science in India, and I hope that all who read it would feel inspired to take this country forward to even greater heights.

G. Venkataraman

Formerly of BARC, IGCAR, and ANURAG/DRDO

Dr. G. Venkataraman, former Distinguished Scientist of DAE is a biographer of Sir C. V. Raman. He has written many books and articles on Prof. Raman.



*Nobel Prize winners of 1930, Raman (Physics), Hans Fischer (Chemistry),
Kart Landsteiner (Medicine) and Sinclair Lewis (Literature)*

SIR C.V. RAMAN DISCOVERY OF RAMAN EFFECT

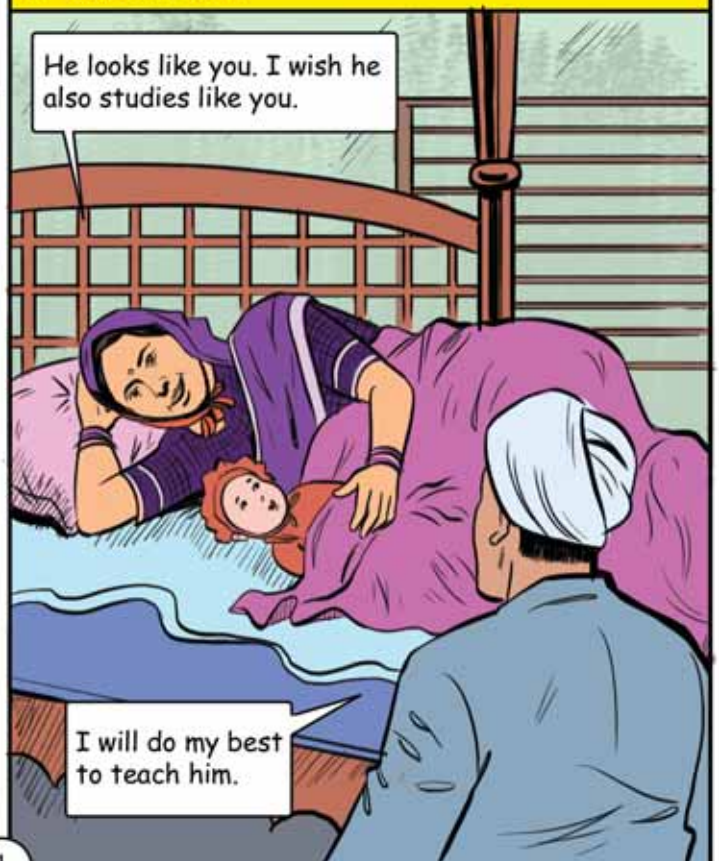
Chandrasekharan Ayyar (Sir C.V. Raman's father) was born in 1866 to an astute Brahmin father Ramanathan and mother Ammal. Chandrasekharan did matriculation in 1881 and was pursuing a B.A. degree at the Madras Christian College in 1884. While Chandrasekharan was graduating, he got married to Parvathy, who belonged to a Sanskrit Scholar family.



In due course of time, Parvathy conceived her first child.



Chandrasekharan and his wife Parvathy were blessed with a baby boy (named C. Subrahmanyam Ayyar) on 8th October 1885.



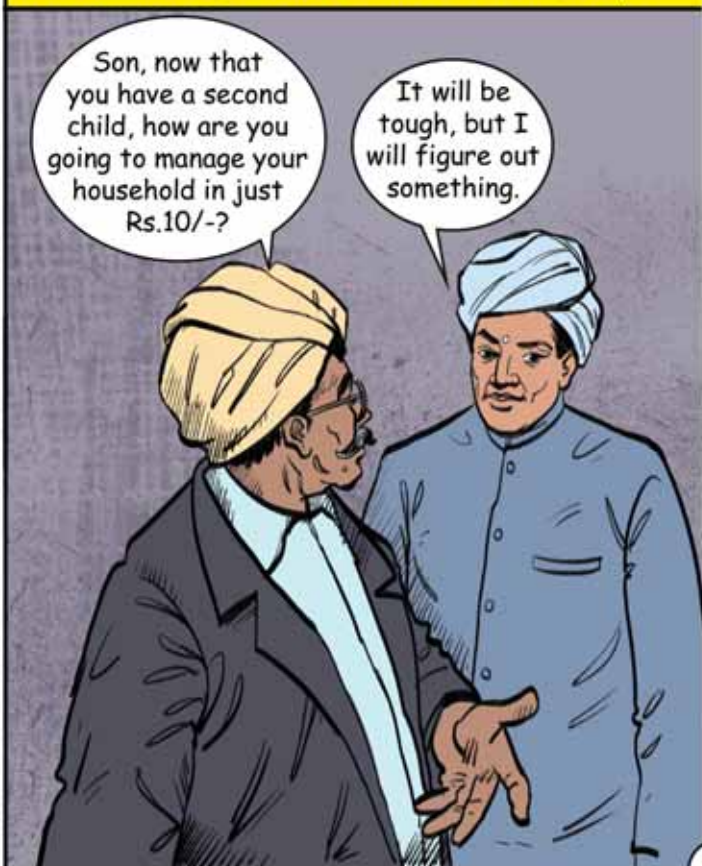
Three years later, on November 7th, 1888, Chandrasekharan's second son Venkata Raman (popularly called Raman) was born at Parvathy's paternal home in the small village of Thiruvanaikkaval near Thiruchirapalli (Tamil Nadu).



When Raman was born, Chandrasekharan was teaching at a high school (attached to SPG College, run by the Society for the Propagation of the Gospels) in Thiruchirapalli. He earned just Rs.10/- per month.

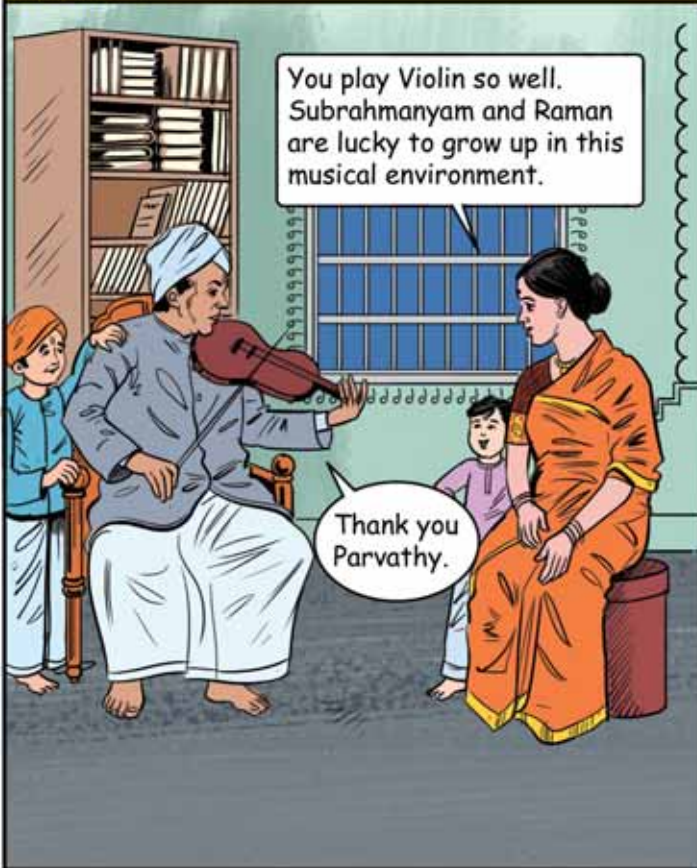


Parvathy's father was worried, how Chandrasekharan will run the house with the meagre salary of Rs. 10/- with addition of two more members in the family.

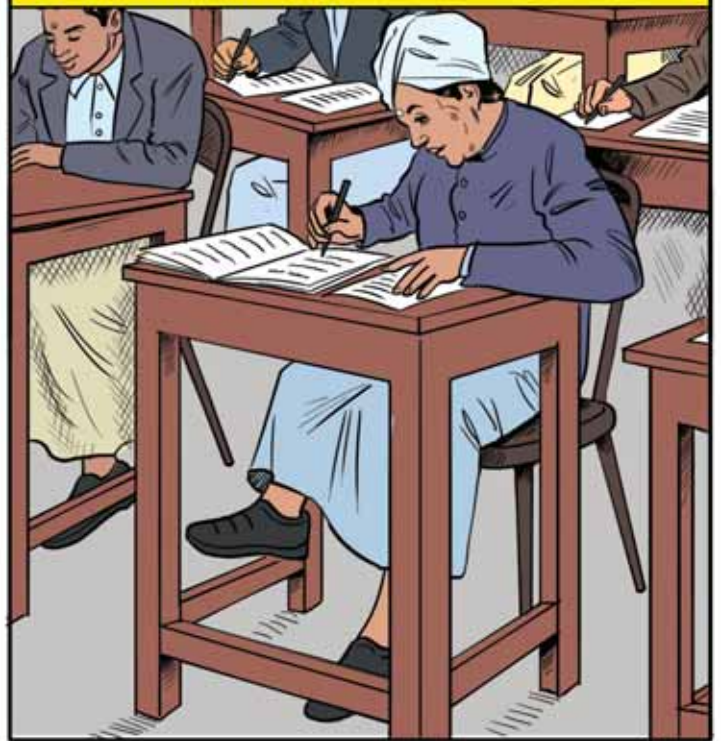


* Appa means father in Tamil.

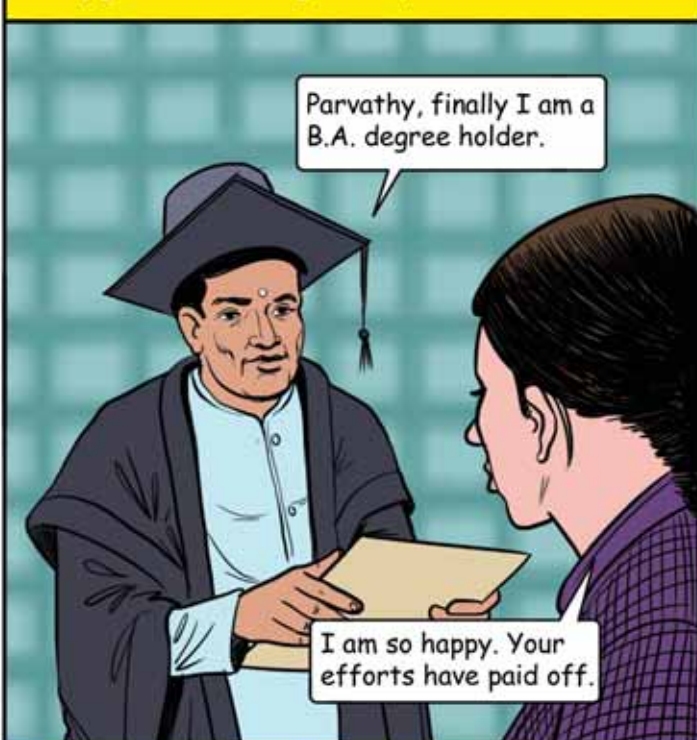
Despite all the ups and downs of life, Chandrasekharan never lost his love for Physics, Mathematics, Philosophy and Music.



During his last attempt of B.A. exam, the rule was that one had to pass all three subjects in the single attempt. Chandrasekharan passed in English and Mathematics but unfortunately, failed in Tamil. The rules of graduation examination changed in early 1889. Chandrasekharan could now take each exam one by one rather than concurrently.

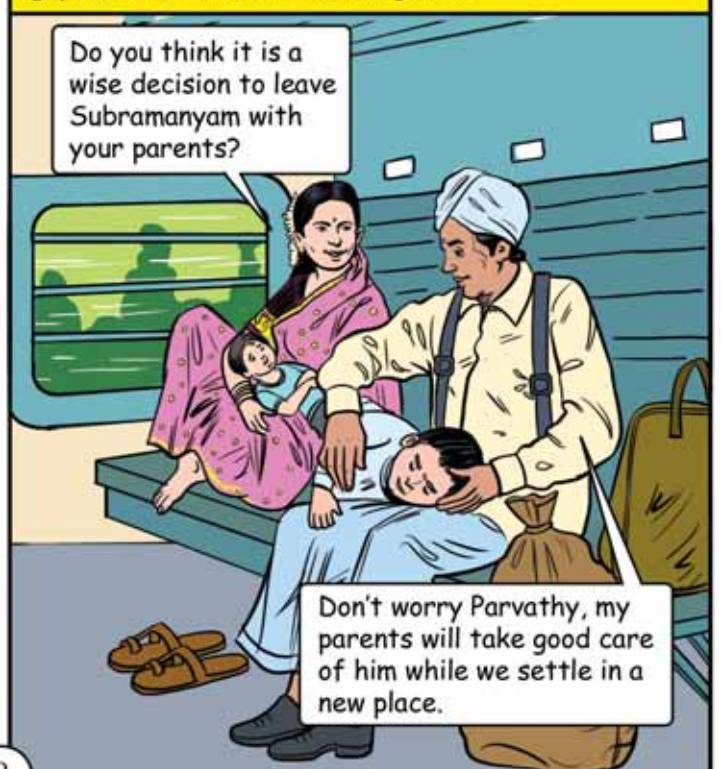


Chandrasekharan worked as a full-time teacher at SPG school and tutored kids of wealthy families to supplement his income. The very next year, in 1892, he finally graduated in English, Physics and Mathematics.



Chandrasekharan and Parvathy had their third child (Mangalam) in 1891.

Now that he was a graduate, Chandrasekharan was appointed to teach at A.V. N. College (Mrs. Ankitam Venkata Narasimha Rao College) in Vizagapatam (now known as Vishakhapatnam) or Waltair as the British called it. Chandrasekharan and Parvathy went to Vizagapatam with Raman and Mangalam.



During those days, the railways were operating only in few places. Hence, the family had to change several modes of transport. They travelled by train, canal boat and bullock cart to get to their destination.



Appa, when will we reach our new house?

It will take about two weeks, Raman.

After few weeks Chandrasekharan went to his parent's home and brought Subramanyam to Vizagapatam. Life was much better for Chandrasekharan and Parvathy in Vizagapatam. Later they had more children, Skandan born in 1894 and Sundaram in 1898.



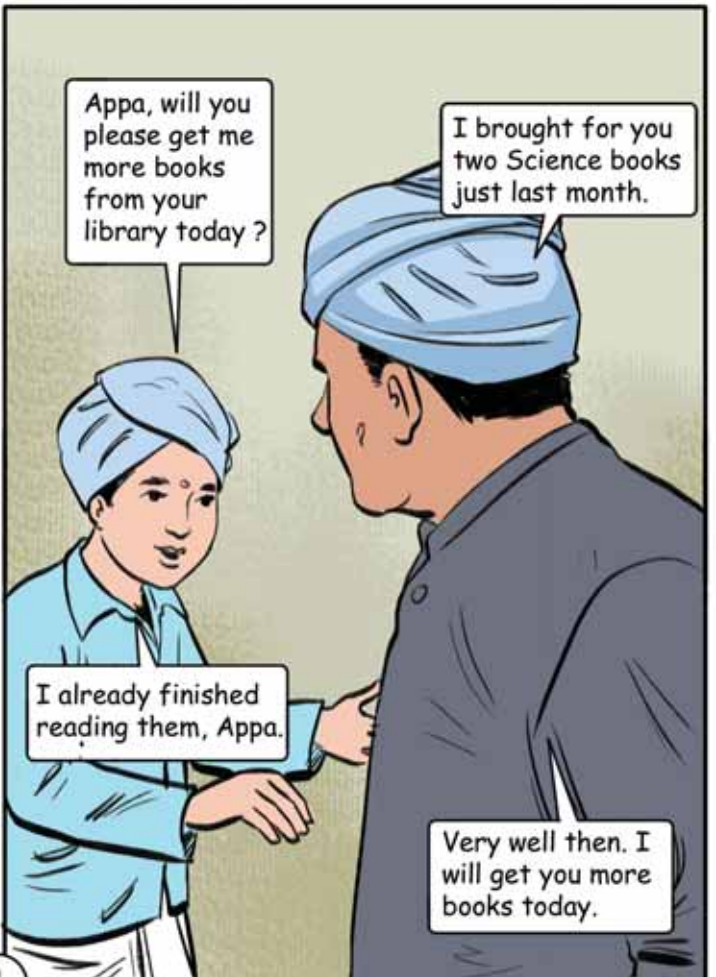
Later Sitalaxmi in 1901, Meena in 1903 and Ramaswamy in 1907 were born to Chandrasekharan and Parvathy.

Apart from being a good teacher, Chandrasekharan was an athlete, a good swimmer and loved being physically fit. Unfortunately, his sons were not interested in anything athletic.



Raman, why are you inside home the whole day? Go out and play some games.

No Appa, I like being indoors with books.



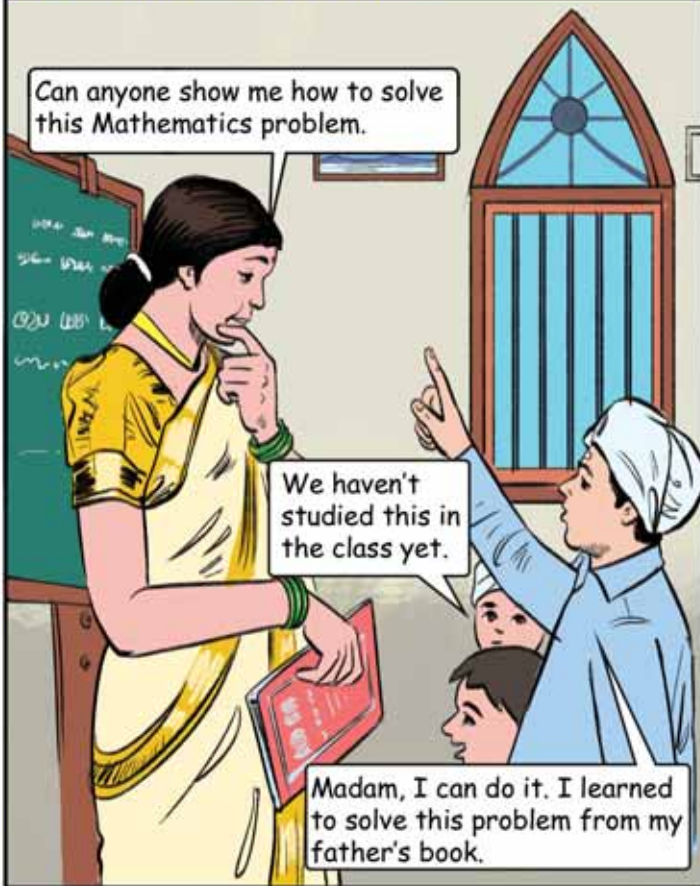
Appa, will you please get me more books from your library today?

I brought for you two Science books just last month.

I already finished reading them, Appa.

Very well then. I will get you more books today.

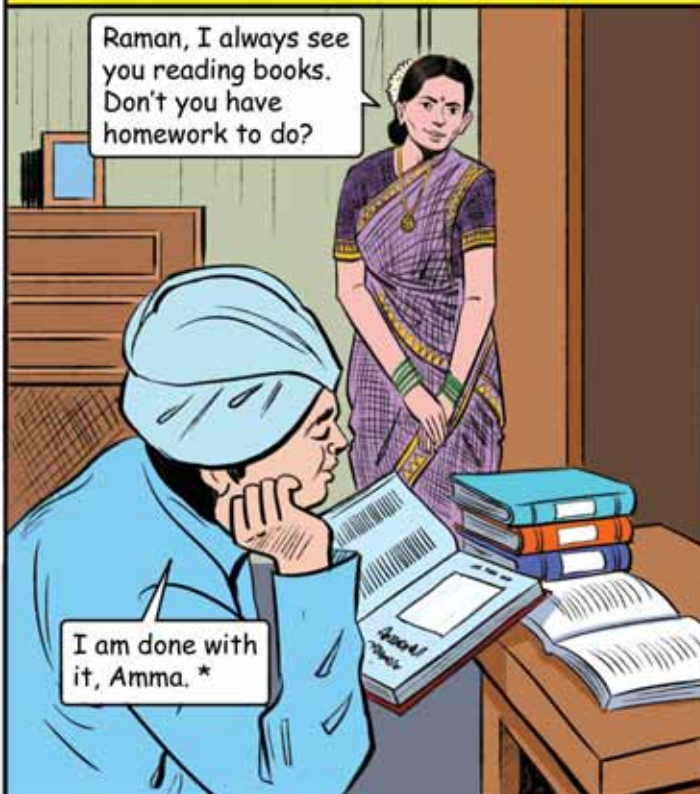
In school, Raman was quick in answering all the questions his teachers put forth.



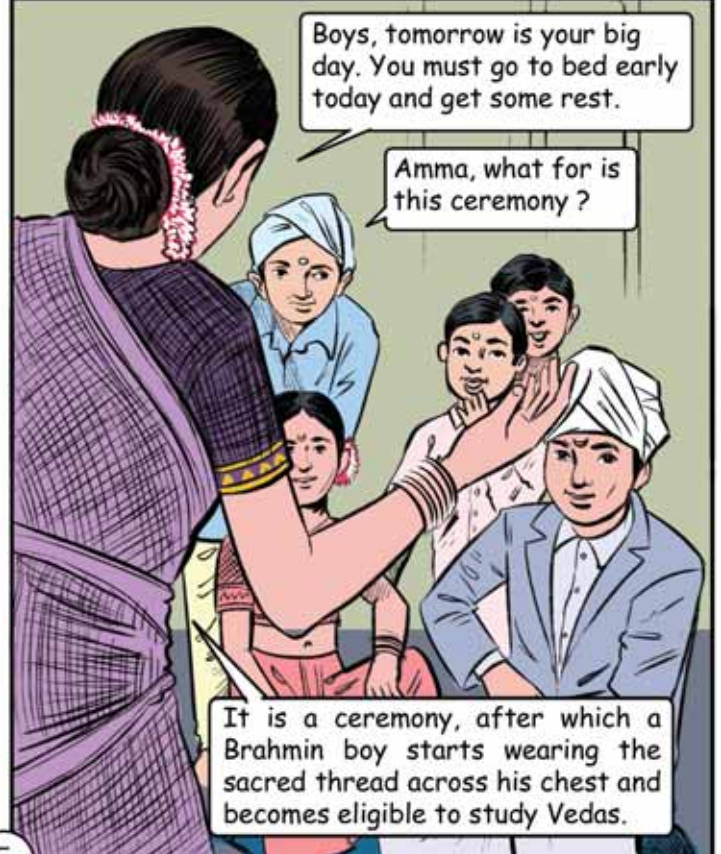
To her surprise, Raman solved the problem without any difficulty.



Raman would read all his books, whether Mathematics, Physics, Geography or Literature before they were taught in his class.



When Raman turned 9 and Subramanyam completed 12 years, their grandfather organised Upanayanam, a sacred thread ceremony for the boys.



*In Tamil, Amma means mother.

Parvathy, I am not comfortable with this ceremony. You know I have turned agnostic, right?

Yes, but for our elders' sake, we must do the ceremony for the boys.

Very well then. But we will let the kids choose their spiritual path.

Throughout his life, Raman cared little for religious rituals. But wore the sacred thread, followed a vegetarian diet and sported a tuft.

When Raman was in middle school, Chandrasekharan took him to his college laboratory.

I have got you here, so you can see how real experiments are done.

Thank you very much, Appa. It is magical to observe the reactions of the chemicals in a test-tube, especially, in the Leyden jar.

Young Raman's life was all about academics. In 1900, at the age of 12, he passed matriculation.

Amma and Anna, I have passed my matriculation exam.

Congratulations Raman, but aren't you too young to have passed this examination?

Anna*, I want to go to college quickly and read all the advanced level books.

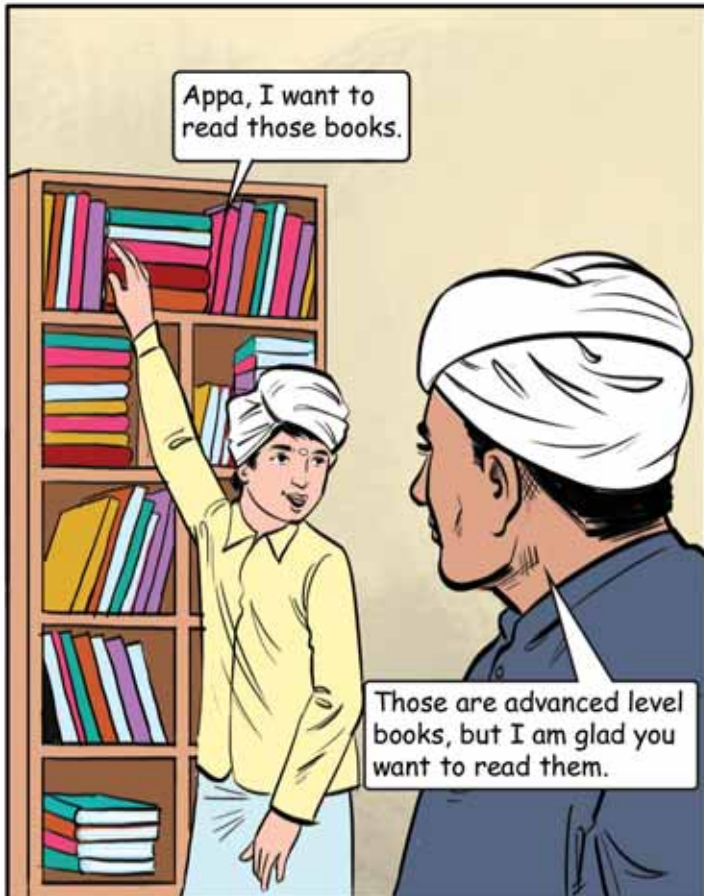
*Anna means elder brother in Tamil.

Raman enrolled in A.V.N College where his father taught. Here also, he devoured all his books, even those that were not his subjects.

So Raman, how many books have you read already?

That's quite a lot.

Sir, Radhakrishnan's Algebra, Smith and Bryant's Geometry, Hall and Steven's Trigonometry and some Greek classics. I love books.



Appa, I want to read those books.

Those are advanced level books, but I am glad you want to read them.

One would always find Raman reading books even when he was not well.

More advanced Mathematics and Physics books were given to Raman, and he read them all.



Raman, Out of the books that you have read, which is your favourite?

Appa, I particularly liked reading Edward Routh's books - "A Treatise on Dynamics of Rigid Bodies, A Treatise on Analytic Statistics and A Treatise on Dynamics of Particles".

Appa, I particularly liked reading Edward Routh's books - "A Treatise on Dynamics of Rigid Bodies, A Treatise on Analytic Statistics and A Treatise on Dynamics of Particles".

Chandrasekharan brought down the classic book by J. C. Maxwell "A Dynamical Theory of the Electromagnetic Field" from the top row of the book shelf.



Raman, I will explain these concepts to you when I come back home after work.

Alright, Appa.

When Chandrasekharan got back home, he realised that Raman had already understood the advanced concepts of the book. Later, Raman read many books on physics and mathematics, the one that inspired and most influenced Raman was "The Sensations of Tone" by famous German Scientist Hermann von Helmholtz. It was this book that gave Raman a variety of problems for research which later occupied his attention and kept him busy for many years.

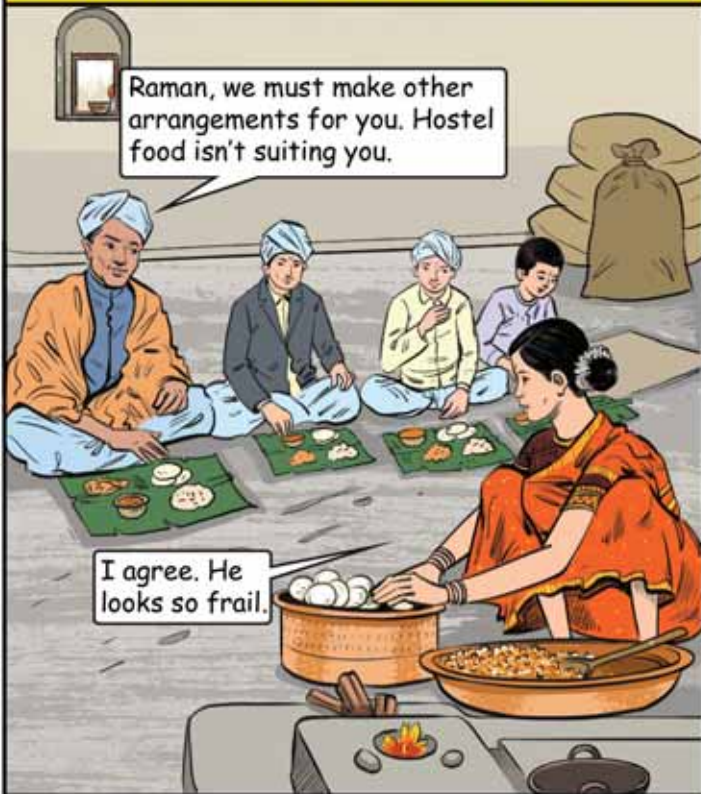
Raman completed his intermediate studies in December 1902. To pursue his B. A., Raman was to move to Madras University. Subramanyam had already moved to Madras the previous year.



I am worried because you are too young.

Don't worry Appa. I will be fine, moreover Anna is also there.

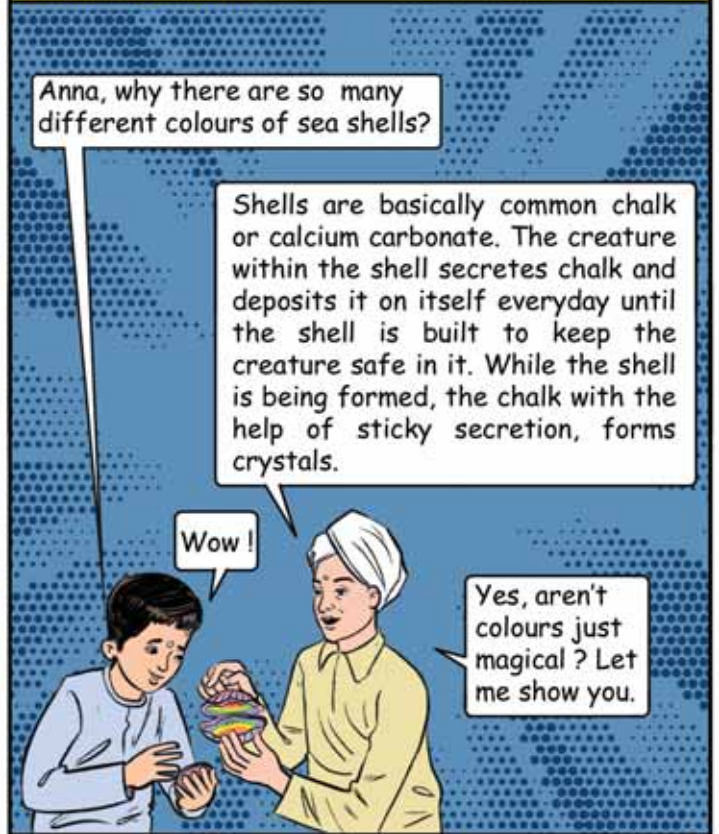
After few months, Raman and Subramanyam returned home in the summer of 1903. Raman had lost some weight. He hardly ate anything at home also. Chandrasekharan was worried about his health. He observed him carefully and looked for any illness.



Raman, we must make other arrangements for you. Hostel food isn't suiting you.

I agree. He looks so frail.

Though Raman had become thin, he was in good spirits and spoke excitedly about his time at Madras particularly about the sea, shells etc. to his younger brother Skandan.

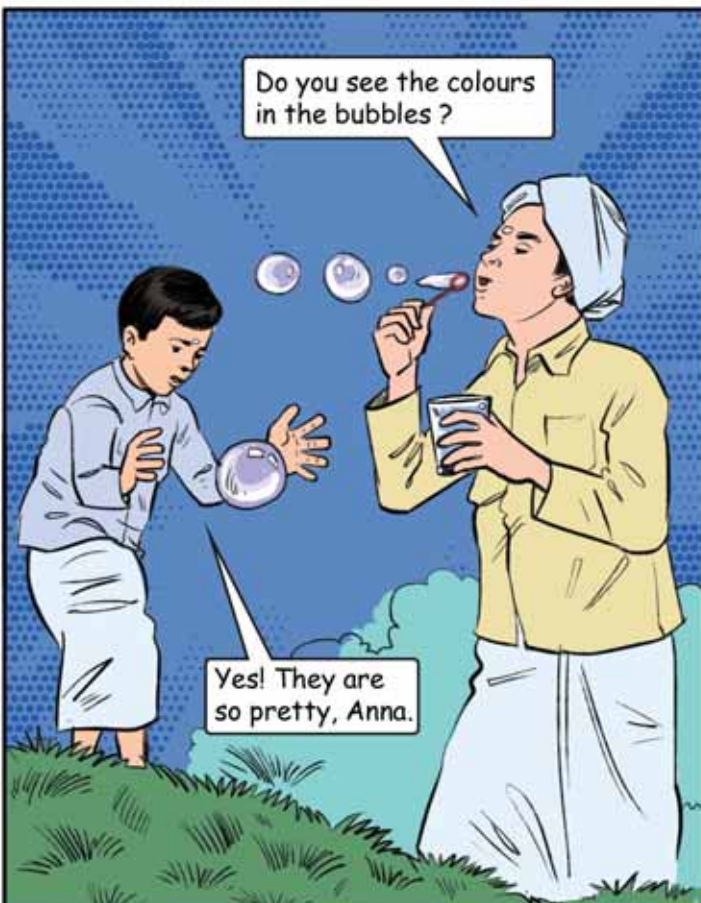


Anna, why there are so many different colours of sea shells?

Shells are basically common chalk or calcium carbonate. The creature within the shell secretes chalk and deposits it on itself everyday until the shell is built to keep the creature safe in it. While the shell is being formed, the chalk with the help of sticky secretion, forms crystals.

Wow!

Yes, aren't colours just magical? Let me show you.



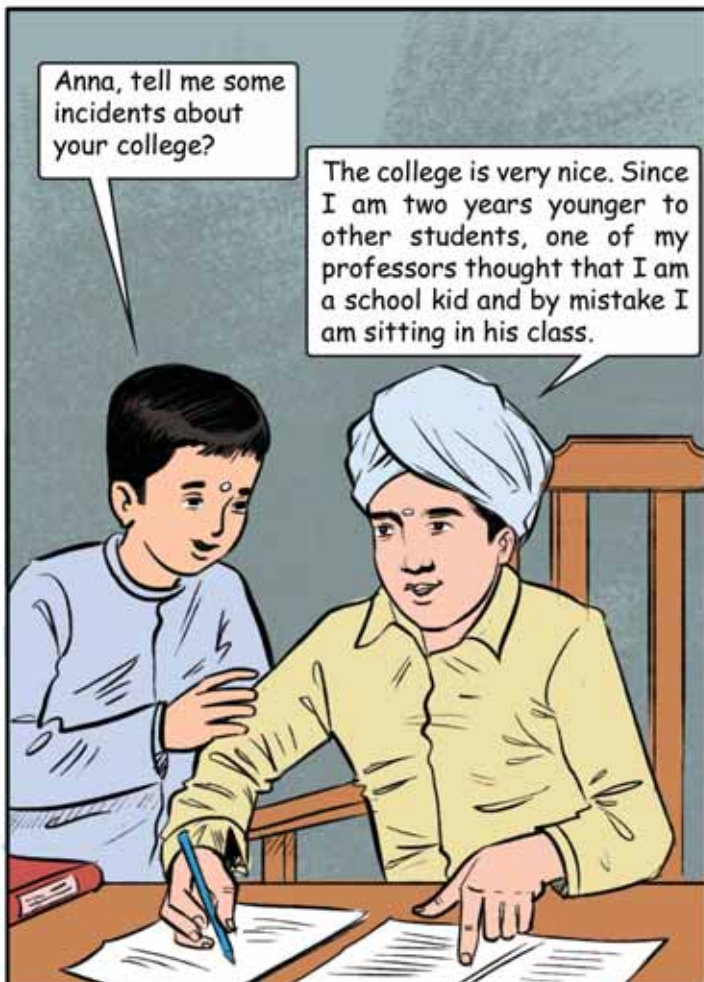
Do you see the colours in the bubbles?

Yes! They are so pretty, Anna.

Skandan had many questions for Raman, which he answered comfortably. He showed his younger brother some simple tricks of light refraction. There was also the trick of making a stick appear broken underwater.



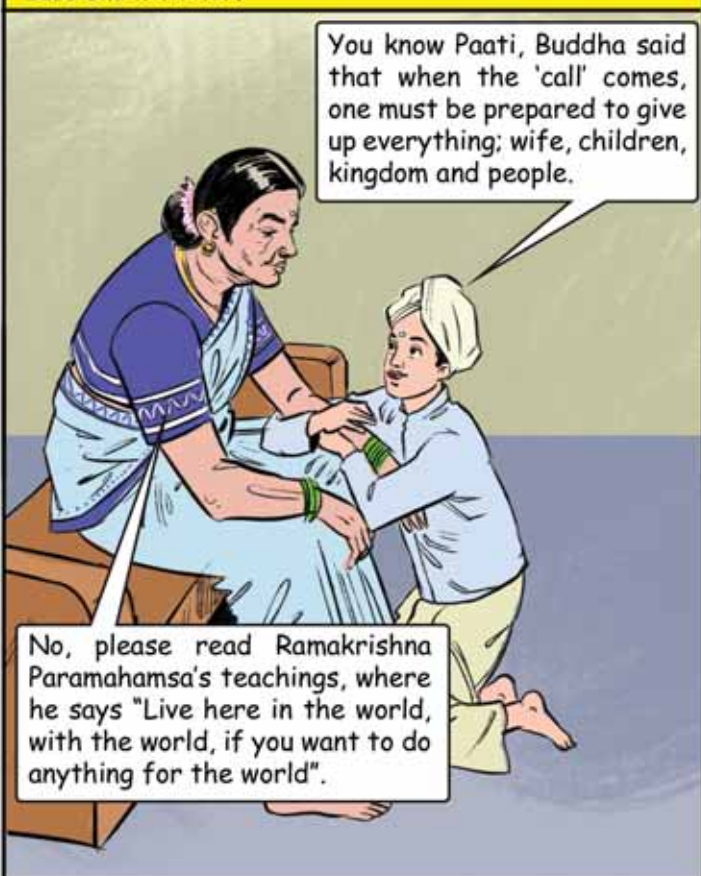
Through bubbles, Raman showed Skandan different colours of rainbow.



Anna, tell me some incidents about your college?

The college is very nice. Since I am two years younger to other students, one of my professors thought that I am a school kid and by mistake I am sitting in his class.

Raman shared an intimate bond with his Paati (grandmother) named Muthuchipi and often had discussions with her.

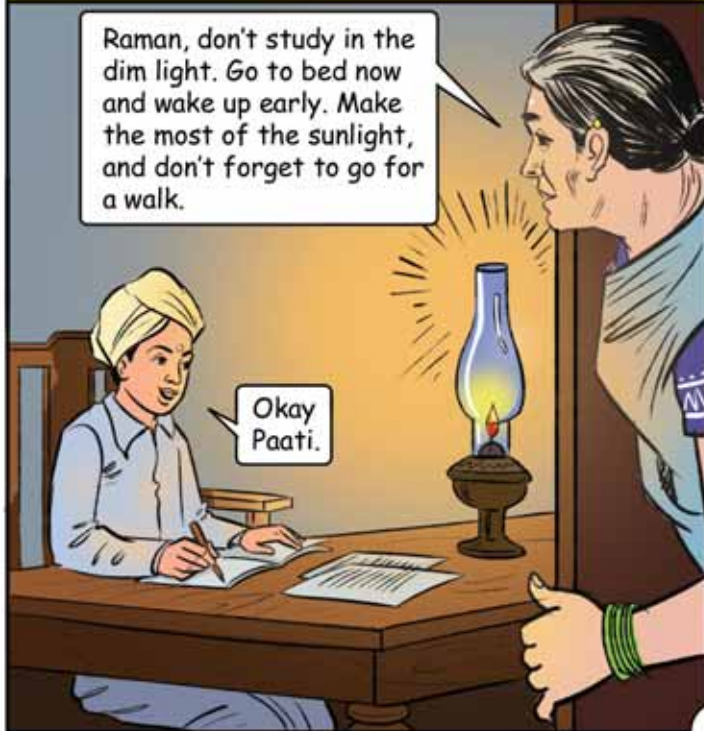


You know Paati, Buddha said that when the 'call' comes, one must be prepared to give up everything; wife, children, kingdom and people.

No, please read Ramakrishna Paramahansa's teachings, where he says "Live here in the world, with the world, if you want to do anything for the world".

Before Raman could go back to college again, his father Chandrasekharan made an arrangement of a house in Madras at 8, Iswardoss Lala Street in Triplicane. In July 1903, Raman's grandparents and also his aunt Gnanam moved with Raman and Subramanyam to Madras. Paati took full charge of not just the household but also the boys' well-being.

Paati made nutritious meals for the boys. She often packed idli, chutney, pickle, rice, rasam and other delicious home-cooked food in the tiffin for them. She also made them carry diluted buttermilk to college. Later in life, Raman would often say that rice with rasam or curd is the ultimate necessity to keep the brain running full steam.



Raman, don't study in the dim light. Go to bed now and wake up early. Make the most of the sunlight, and don't forget to go for a walk.

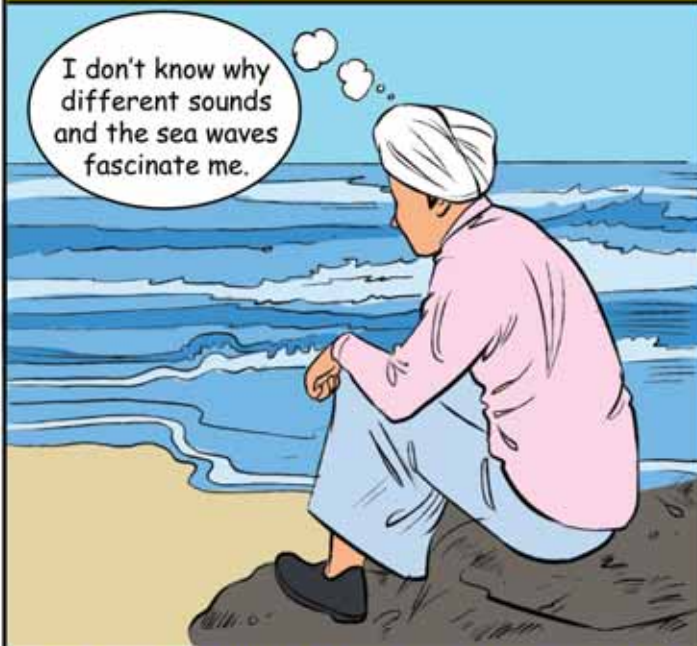
Okay Paati.



I wish you had your father's physique.

Paati, you are a nag, but I still love you.

After Subramanyam's return to Vizagapatam, Raman was left alone in Chennai. The long walks on the beach considerably improved Raman's health. So much so, that he would cycle a long distance. He also continued to study hard and was always passionate for conducting science experiments.



By the end of 1903, Subramanyam earned his B.A. degree and went to Vizagapatam to study for the entrance exam of Civil Services.

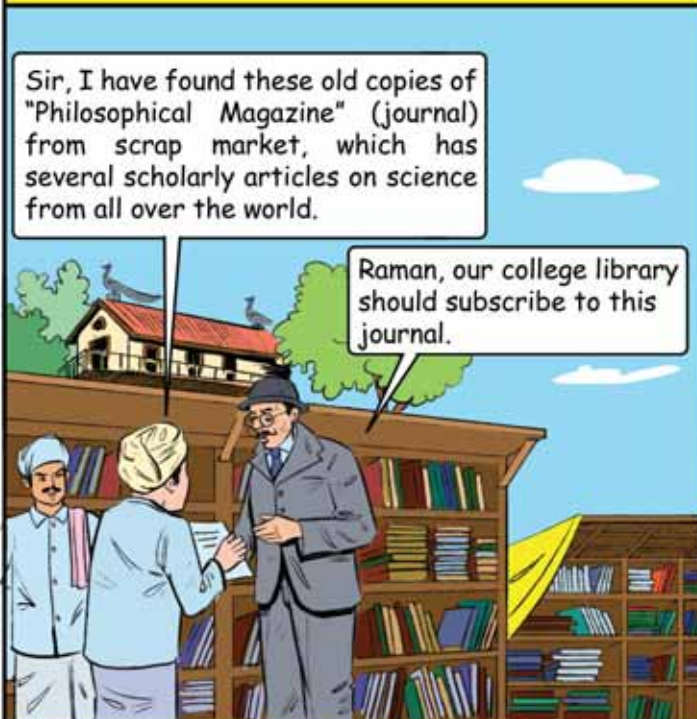
Sir Jones, I have so many new research ideas.

What if they are already done in Europe? Raman you must be abreast with what is happening in Europe.



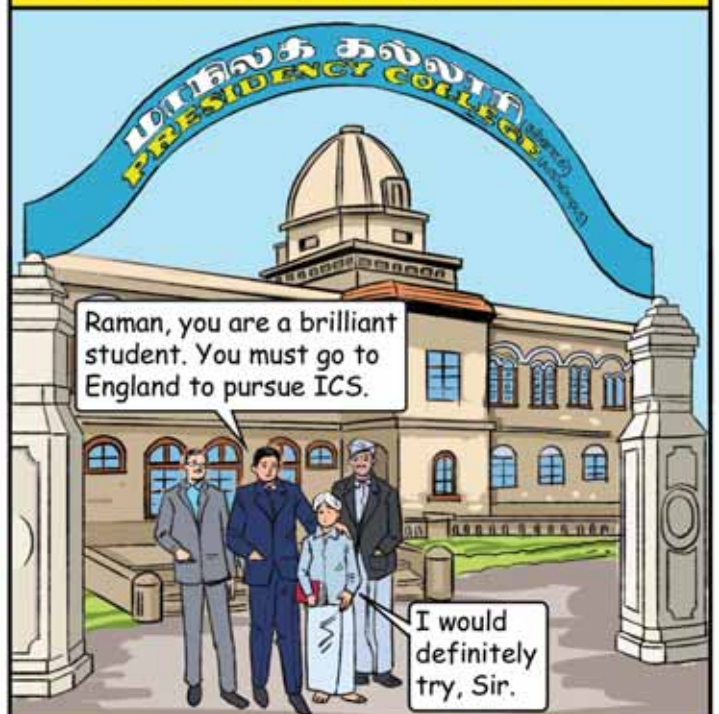
Raman had no resources in terms of scientific journals or information to know what is happening in the world of science.

Raman found a way to get access to more books. He would often go to the Connemara Library and Moore Market. The latter had several second-hand books left by British soldiers and officers returning to Britain.



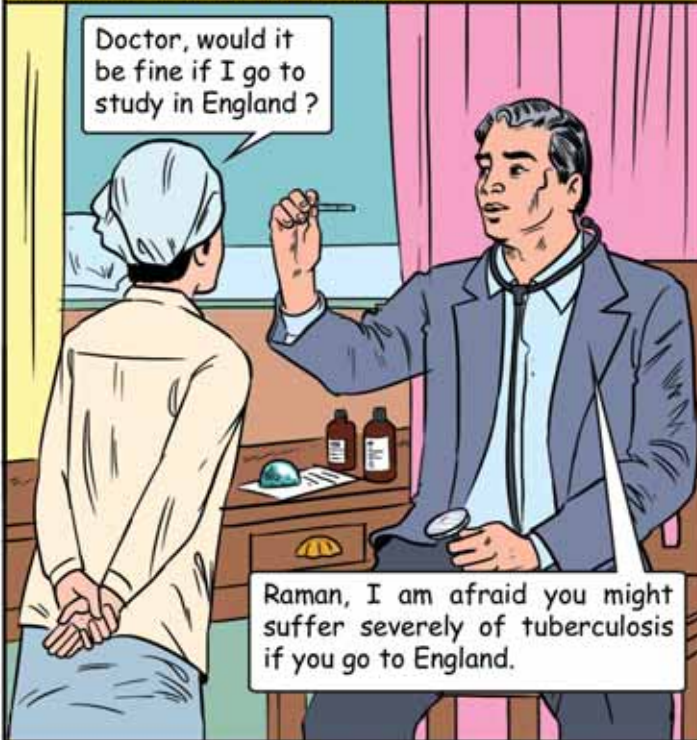
The presidency college finally started subscribing to the philosophical magazine, but only after Raman had graduated.

Raman was always a student of the first rank and voracious reader. He studied very hard and won the English and Physics Gold medals at his college. His teachers suggested that he should go to England to prepare for the Indian Civil Service (ICS).*



*The ICS was the forerunner of today's Indian Administrative Service (IAS).

Raman went to see a doctor to get himself medically checked before going to England.

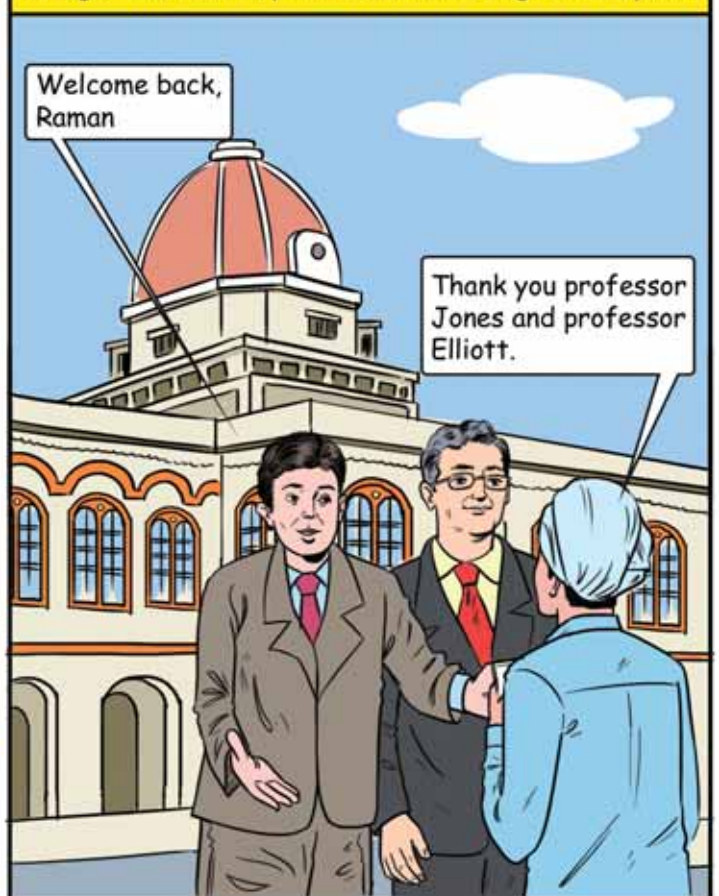


Doctor, would it be fine if I go to study in England?

Raman, I am afraid you might suffer severely of tuberculosis if you go to England.

Raman decided to continue his studies in India. This was the only examination (medical) that Raman ever failed and in later years Raman said about this medical officer, "I shall ever be grateful to this man!"

In January 1905, Raman was back at the Presidency College. This time to pursue a Master's degree in Physics.



Welcome back, Raman

Thank you professor Jones and professor Elliott.

Ever since his B.A. days, many professors allowed Raman to miss classes and work on his research instead. They knew his intelligence and knowledge was superior to most of the students of his class. For some subjects, his understanding was equivalent to some of his professors.

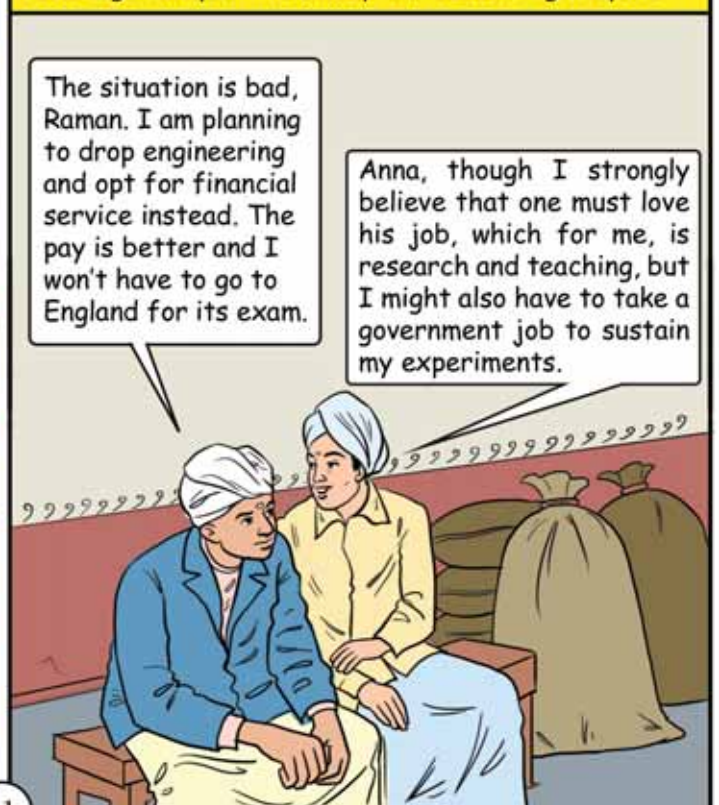


Do you intend to spend most of your time in the lab this time also?

Yes, Sir. But I promise that I will learn everything being taught in the class as well. I already have learnt most of it.

During the whole of his two years' studies for the M.A. degree, Raman attended only one lecture!

While Raman's research was going well, he was worried about what his elder brother had told him about his family's financial crisis. The several loans taken on their ancestral land and the dowries for sisters' weddings had put the family in financial tight spot.



The situation is bad, Raman. I am planning to drop engineering and opt for financial service instead. The pay is better and I won't have to go to England for its exam.

Anna, though I strongly believe that one must love his job, which for me, is research and teaching, but I might also have to take a government job to sustain my experiments.

Raman was very sharp and highly focused on the scientific question to be answered.

Raman, will you be able to do all the advance experiments you want to with the available equipment in our lab ?

Yes, with the sharpness of mind you can very well do that and I believe that if you ask the right question, the nature will reveal itself.

Well said, Raman.



Raman wrote a paper on "Unsymmetrical diffraction bands due to a rectangular aperture observed when light is reflected obliquely at the face of a prism". He gave it to Professor Jones for his comments.

I would like to hear your feedback, Sir.



But even after several days, Raman didn't hear from Professor Jones.

Paati, my professor has not given any feedback about my paper.

Does it mean that your hard work will go waste ?

Why don't you do it then ?

Not really, I can communicate it myself directly to the Journal.



Raman sent his long paper to the Philosophical Magazine. He wrote his credentials as - Demonstrator in Physics at The Presidency College, Madras.

Philosophical Magazine

[494]

LV. Unsymmetrical Diffraction-bands due to a Rectangular Aperture. By C.V. Raman, Demonstrator in Physics at The Presidency College, Madras*.

When a pencil of monochromatic light coming from a slit in the focal plane of a collimating lens falls upon the object-glass of a telescope in front of which a narrow rectangular aperture is placed with its sides parallel to the luminous slit of the collimator,

* Communicated by the Author.

Raman decided to communicate his paper without Prof. Jones's comments.

The paper was published in Philosophical Magazine, Raman C.V., 12 (1906) 494-498.

Raman's heart was clearly in science but opportunities for Indians for a research career in India did not exist then. Going to England was also ruled out because of his poor health. Raman appeared in The Indian Financial Service exam. He wrote another research paper and that got published in the Philosophical Journal as well.



After reading Raman's paper, eminent scientist Lord Rayleigh (UK) wrote to Raman, addressing him as Professor Raman, not knowing that Raman was just 18-years-old.

Raman's family was thinking of his marriage. This news reached his college friend Ramaswami Sivan who was a radicalist.



I understand you are likely to marry soon.

Sivan, let's see how it goes.

Raman, I am looking for a suitable match for my sister-in-law. Would you like to meet her?

OK. If you wish so.



In early May 1907, on one day Sivan had gone out and Lokasundari (known as Lokam) was practicing on her Veena, playing one of Tyagraja kriti: "Raama nee samanam evaro" (Rama, there is no one comparable to you.) Raman knocked at Sivan's house. Sivan's wife (Laxmi) opened the door.

Is this Sivan's house? The one who has a sister-in-law of marriageable age?

Yes.



Raman and his friend left after some time. Laxmi didn't like Raman's bluntness.

When Sivan came back home, Laxmi mentioned to him about Raman's visit.

I know you are keen on finding suitable match for our Lokam, but do you need to get someone straight from the asylum, with a big nose and elephant eyes?



Did Raman come here? Oh, I missed him. Raman is my good friend and he is a brilliant guy. I think Lokam and Raman would make a good couple.

On 16th May 1907, Sivan arranged a formal visit of Raman along with his brother and a friend at his house, Coffee, Bajji and Sujji (Wheat let Sweets) were served. Lokam was called in to play the Veena. After she played Veena, Sivan introduced Lokam to Raman.



This is not the same tune, that I heard the other day.

She was playing another tune the other day.

Anna, I think Lokasundari is best suited for me. Her shyness and defiance appealed me. She is the one for me. I plan to write to Sivan and convey the same.

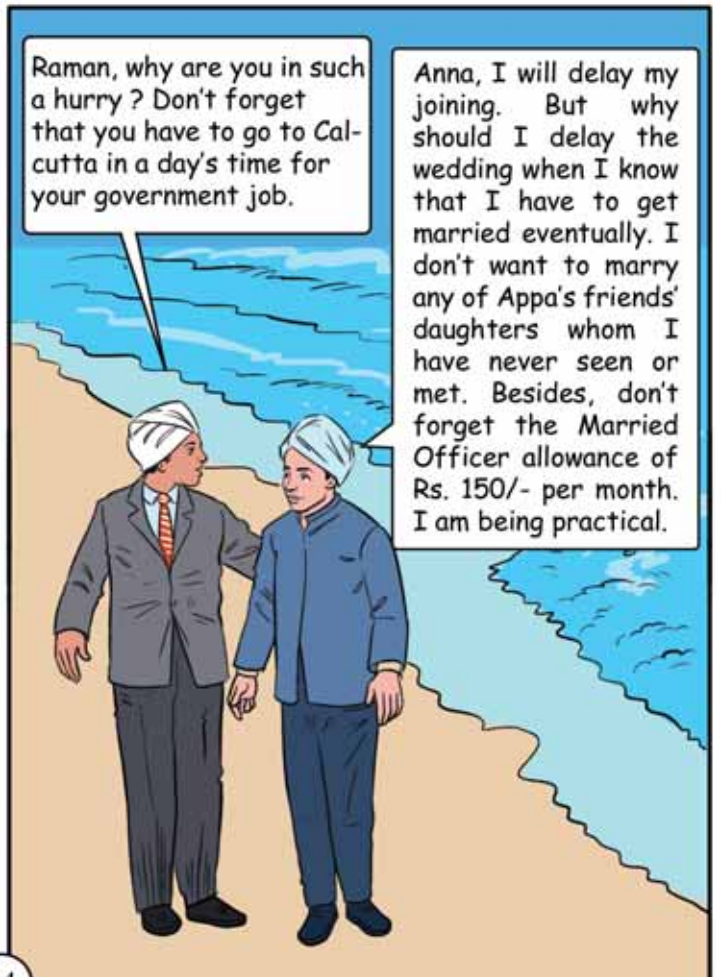
But shouldn't you let Appa know about your meeting with Lokasundari?



Don't worry, he will agree. She is from a good family.

Raman, why are you in such a hurry? Don't forget that you have to go to Calcutta in a day's time for your government job.

Anna, I will delay my joining. But why should I delay the wedding when I know that I have to get married eventually. I don't want to marry any of Appa's friends' daughters whom I have never seen or met. Besides, don't forget the Married Officer allowance of Rs. 150/- per month. I am being practical.



Raman wrote to Sivan informing him about his decision to delay his moving to Calcutta. He also expressed his desire to stay at Sivan's house to know Lokasundari better and understand if they are compatible. Within two days Sivan received a letter from Raman



18th May, 1907

My dear Sivan,

I have postponed my journey to Calcutta by a week, if not a fortnight. I shall certainly not start before the 28th of this month.

I am under the impression that your sister-in-law is certainly in every respect, except that of personal attraction, infinitely superior to any other that I know of. I am almost but by no means perfectly certain that if I marry her, I shall be happy with her. But unless I am perfectly certain about this, I think I shall not be justified in making an offer of marriage.

In order that I might make up my mind upon this subject, it is necessary that I should have some slight degree of personal acquaintance with her. Seeing that we have gone so far and that I am prepared to disregard the conventional prejudices against intersectal marriage, I think you can permit this. A stay of a day or two at your house will suffice.

If you can consent to this, will you kindly write to me. I can then come over and be introduced to her. The matter can then be settled. Further, it is necessary that she should consent to the marriage. I should be the last person to inflict myself on a girl like your sister-in-law. Will you kindly take her opinion - her unbiased opinion on the subject - and write to me.

Yours sincerely,

Raman

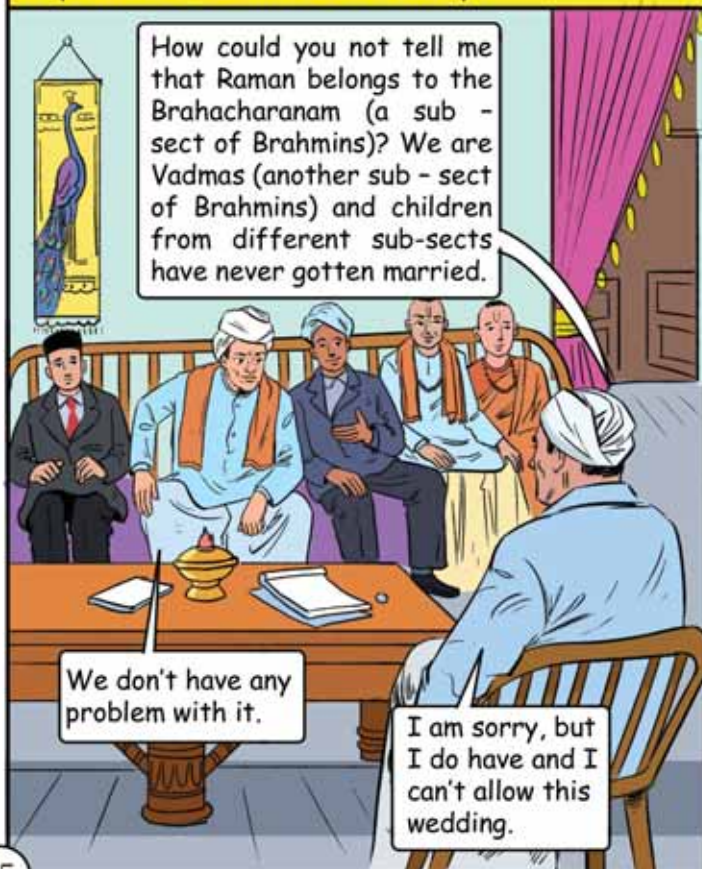
P.S.: When I come over, I shall bring down the specs, book on surface tension, diffusion etc.

Sivan diplomatically refused Raman's unconventional request and promised him to speed up the wedding process. The wedding was fixed for May 28, 1907 and both the families were informed about it.

Raman and Lokasundari's families were upset about not taking their consent before finalising the wedding. However, they still reached Madras from their respective homes (in Vizagapatam and Madurai) to bless the couple.



But not everything went as planned. Lokasundari's father was upset and wanted to cancel the wedding in presence of Raman and his family.



The wedding was cancelled, but Raman, his father and Sivan did not give up. Raman talked to Panditji to intervene and convince Lokam's father.

Panditji, you and your friends are respected by the entire Brahmin community. You must convince Lokam's father to let her marry me.

While the Vedas do not disallow wedding between the two sub-sets, it has never happened earlier. But I will try to convince Lokam's father.



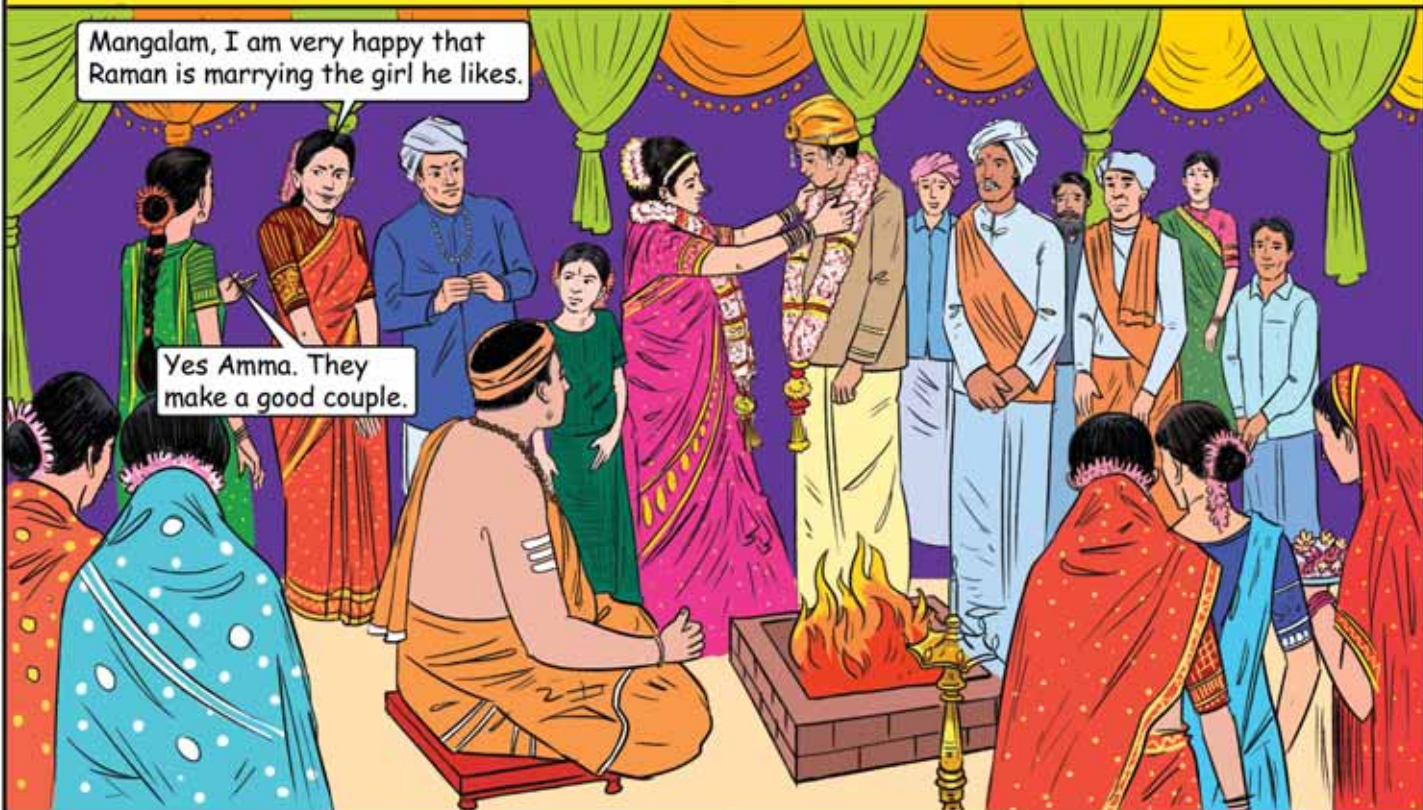
As pandits, we assure you that you won't be expelled from the community. In fact, we will all come for the wedding and bless the couple.



Lokam's father finally agreed for the marriage. Raman and Lokam got married on Sunday, June 2nd, 1907 with the blessings of their families and community.

Mangalam, I am very happy that Raman is marrying the girl he likes.

Yes Amma. They make a good couple.

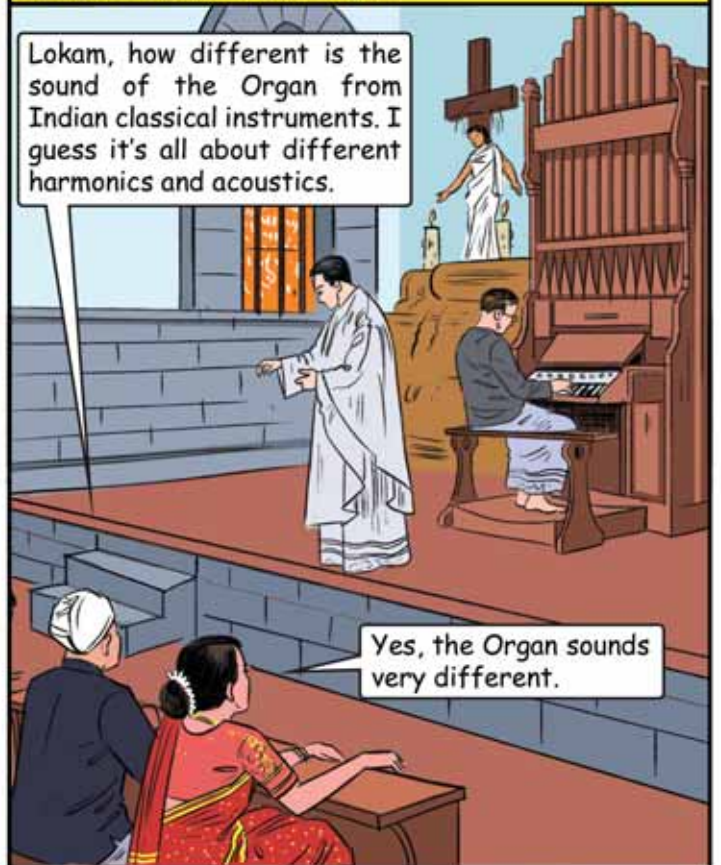


Back then, the inter-sectal marriage was so revolutionary that "The Hindu" newspaper reported about their wedding.

After the wedding celebrations, Raman along with Lokam accompanied by his mother and two sisters moved to Calcutta. Raman started his work in Calcutta (The then capital of British India) as an Assistant Accountant General.



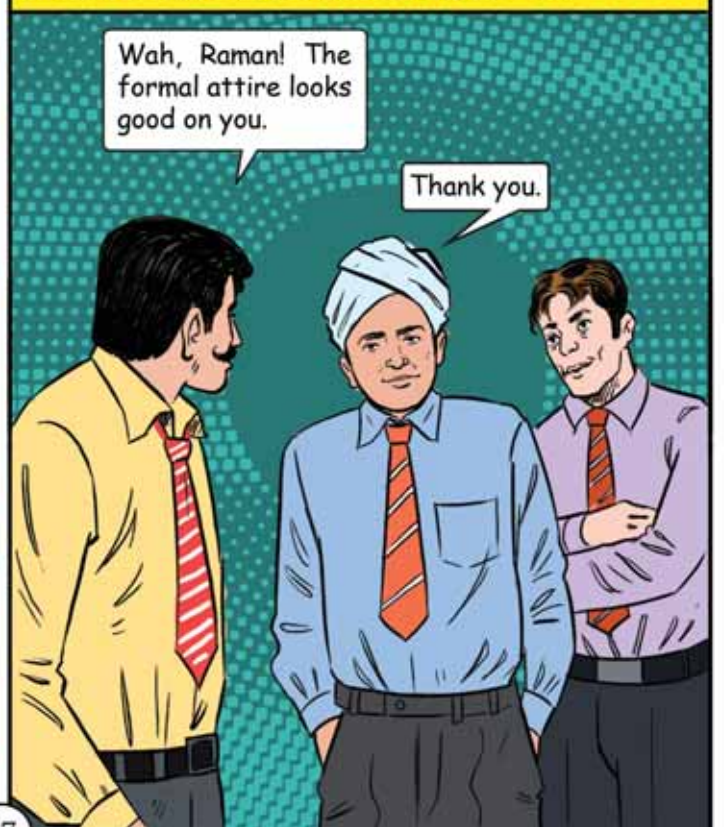
There was a church down the lane from Raman's home. On one Sunday, he decided to take Lokam and his two sisters to listen to the Organ.



After few weeks Raman's mother and sisters left for Vizagapatam, leaving Raman under Lokam's care.



At the office, Raman was learning the importance of dressing formally. He realised that he will have to look like an officer, and dress appropriately to get his colleagues and subordinates to respect him.



While Raman and Lokam were settling in Calcutta, they came to know about the demise of his ten-year-old brother Sundaram who died due to an acute attack of dysentery at Vizagapatam.

I feel sad for my little brother. How fragile life is.

That's true. I still can't completely get over my healthy 19-year-old brother's sudden death last year. These incidents make me sad and I feel terribly homesick.



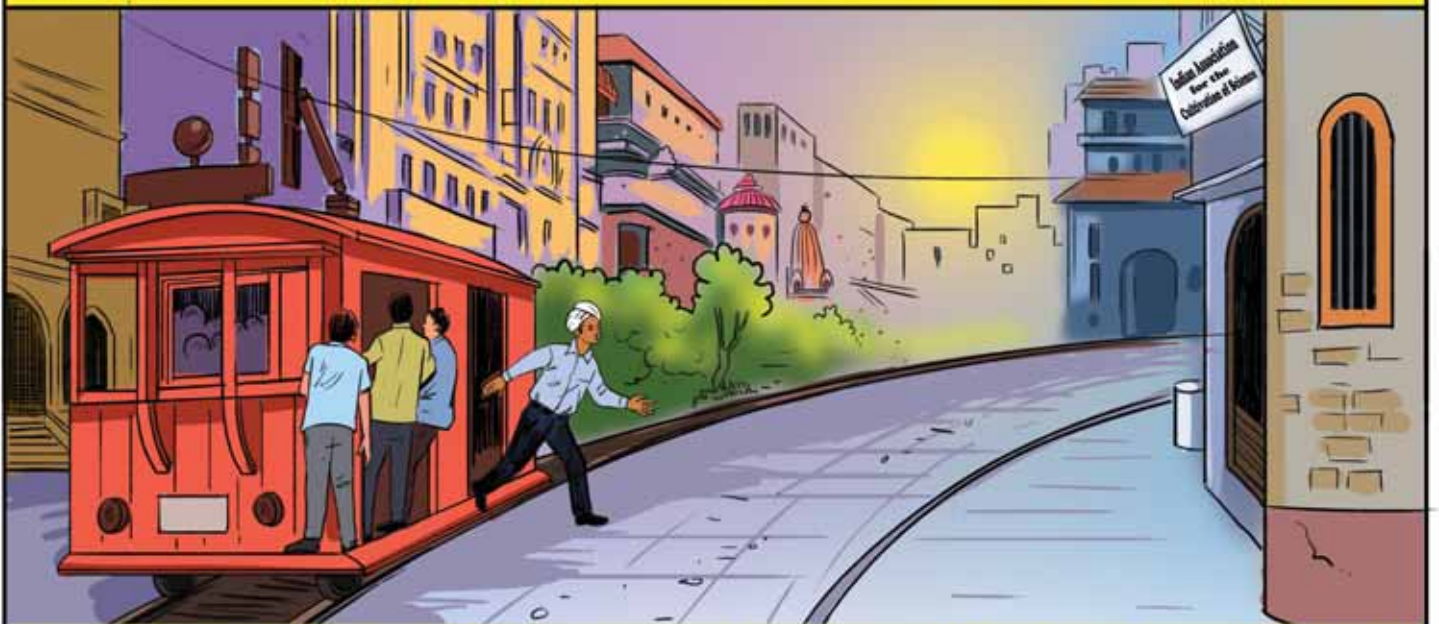
Soon the homesickness of Lokam found an end as Subramanyam and his wife, Seetha, moved to Calcutta in August 1907. Lokam finally had somebody to talk, during the long and lonely afternoons when Raman was away in the office.

Are you and Raman okay here?

I used to feel lonely. Now that you are here, I am fine. Raman misses working in a laboratory and feels sad which disturbs me.



Raman's exile from his favourite place, a laboratory, ended soon. One day while on his way back home from the office, he saw a big board on a building that read "Indian Association for the Cultivation of Science (IACS). He jumped out at the next stop and walked back to the signboard at 210, Bow Bazar Street, Calcutta. Raman went into the IACS building and met Ashutosh Dey, an assistant to the Secretary of the IACS, who later became Raman's supporter for next 25 years.

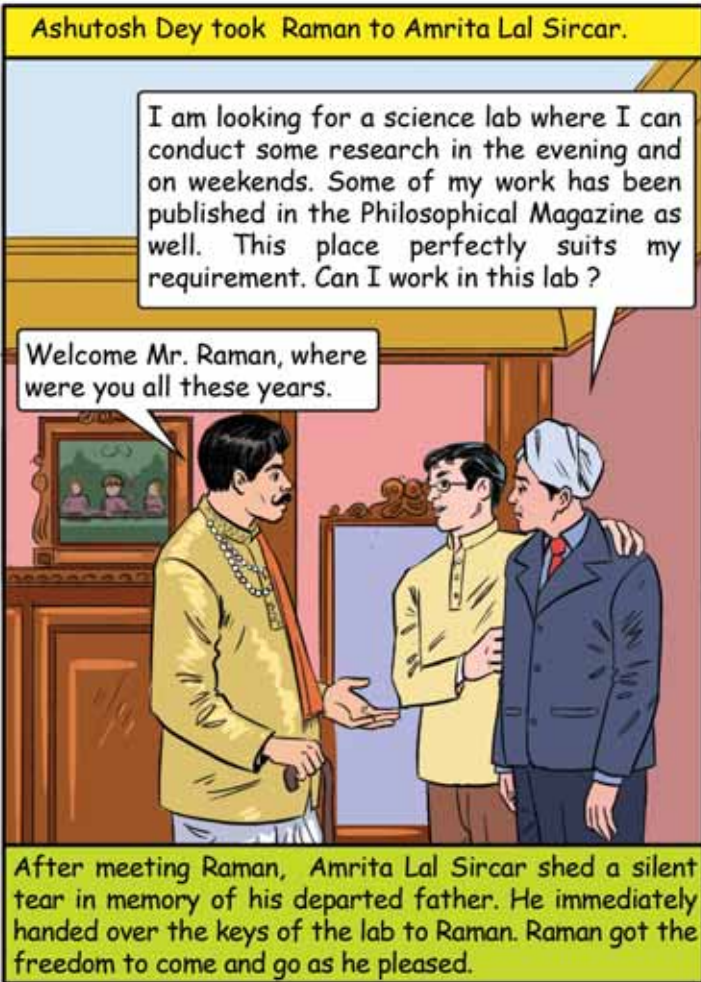


IACS was founded on 29th, July, 1876 by Dr. Mahendra Lal Sircar (born in 1833 in Calcutta). He obtained the M.D. Degree from Calcutta Medical College and was a nationalist. Together with his friends, he founded IACS for scientific research on the pattern of the Royal Institution of London. He died in 1904 and till death served IACS as Hon. Secretary. His son Amrita Lal Sircar then took over the charge of Secretary IACS.



Can I meet the Secretary ? Why is no one working in such a big, lab?

It used to be a buzzing place a few years ago, but it is sadly, desolate now.



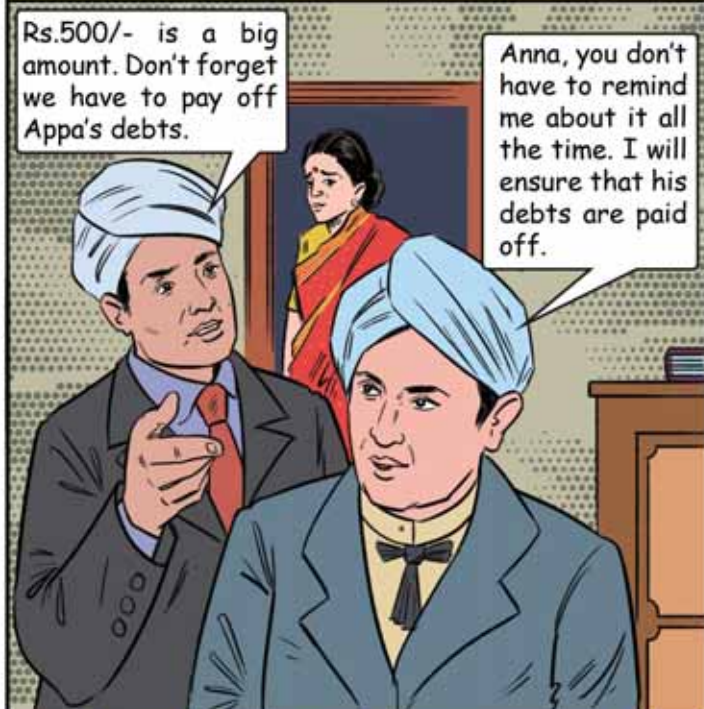
Ashutosh Dey took Raman to Amrita Lal Sircar.

I am looking for a science lab where I can conduct some research in the evening and on weekends. Some of my work has been published in the Philosophical Magazine as well. This place perfectly suits my requirement. Can I work in this lab ?

Welcome Mr. Raman, where were you all these years.

After meeting Raman, Amrita Lal Sircar shed a silent tear in memory of his departed father. He immediately handed over the keys of the lab to Raman. Raman got the freedom to come and go as he pleased.

While Subramanyam was glad to know that Raman had finally found a place to pursue his interest, he was unhappy about Rs.500/- Raman had paid towards the Observatory Fund.



Rs.500/- is a big amount. Don't forget we have to pay off Appa's debts.

Anna, you don't have to remind me about it all the time. I will ensure that his debts are paid off.

The tension between the brothers soon eased. They and their wives got settled in the new home with each other's help and support.

Raman started spending most of his time at the laboratory. At 5:30 a.m. Raman would go to the association, and return at 9:45 a.m. would take bath, gulp his food in haste and leave for office, invariably by taxi* so that he might not be late. At 5 p.m. Raman would go directly to the Association on the way back from work. Sundays, whole day at the IACS.



[* In those days there were no cars; by taxi is meant here a horse-drawn carriage]

Meanwhile, Seetha had exciting news to share with Lokam.

Lokam, there is something I want to tell you.

What is it?

I am pregnant.

That is great news. I am so happy.

Seetha and Subramanyam were blessed with a baby girl (named Rajalakshmi) on January 28th, 1908.

While Lokam's days were filled with the little baby's arrival, it made no difference to Raman. His complete focus was on his work.

Rajalakshmi, is such a bundle of joy, we are blessed to have this little angel.



Chandrasekharan visited Calcutta to see his granddaughter, Rajalakshmi. While he was in Calcutta, he made Subramanyam practice few songs which he had already learnt. But Raman was busy trying to decode the science behind the movements at the Violin strings.

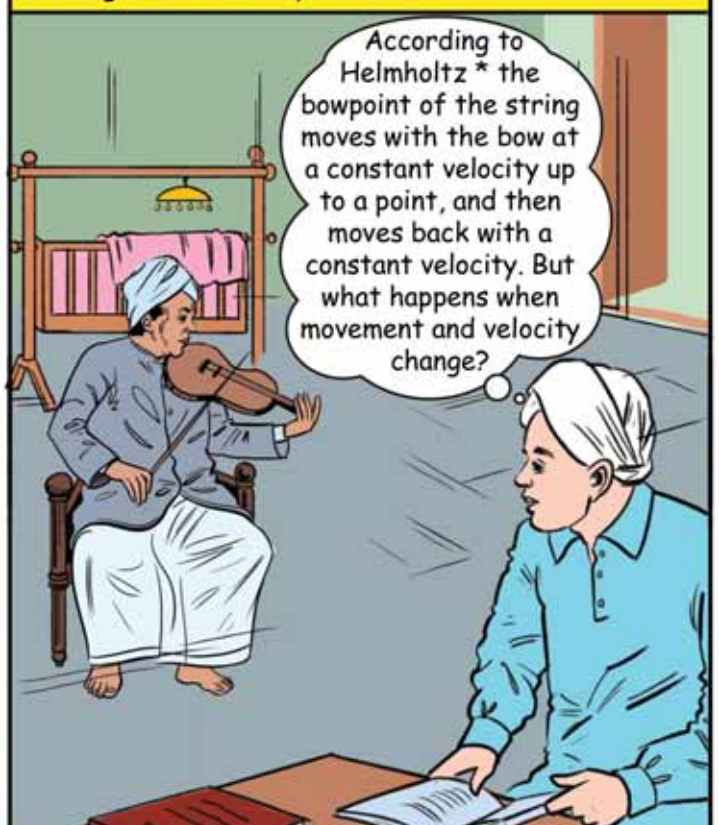
What kind of vibrations are being created by the bow hair as they slipped over the string? How does the shape of the bridge affect the sound?



Later, Chandrasekharan gifted his violin to Subramanyam.

Every time Subramanyam played Violin, Raman's mind would get filled with questions.

According to Helmholtz * the bowpoint of the string moves with the bow at a constant velocity up to a point, and then moves back with a constant velocity. But what happens when movement and velocity change?



* "The Sensations of Tone" by famous German physicist Hermann von Helmholtz.

Meanwhile, Raman organised the IACS workshop and got necessary equipment made on site. Now Raman had variety of instruments and equipment such as Hertz's circular wire resonator, heaters, conical brass vessels to measure boiling point and two steel pulleys for his work with Melde's experiment.



Raman also started a Research Bulletin titled "Bulletin of the Indian Association for the Cultivation of Science". The first issue of this Bulletin came out in 1909.

Raman and Lokam were both having a good time in Calcutta, but their stint in the city came to an abrupt end in early 1909. Raman was promoted to Currency Officer and transferred to Rangoon.



I am not happy with this move. Where will I find a science lab in Rangoon?

I will also feel very lonely there.

Unfortunately, nothing can be done. We will have to go.

Almost a week after arriving in Rangoon, Raman set up a small lab in his house. As a Currency Officer, he was not supposed to leave the place where the currency was stored (his house).



It's a blessing in disguise. I will now have a valid reason to not socialise. I can devote full time to work in the lab.

I am also happy that you will be around.

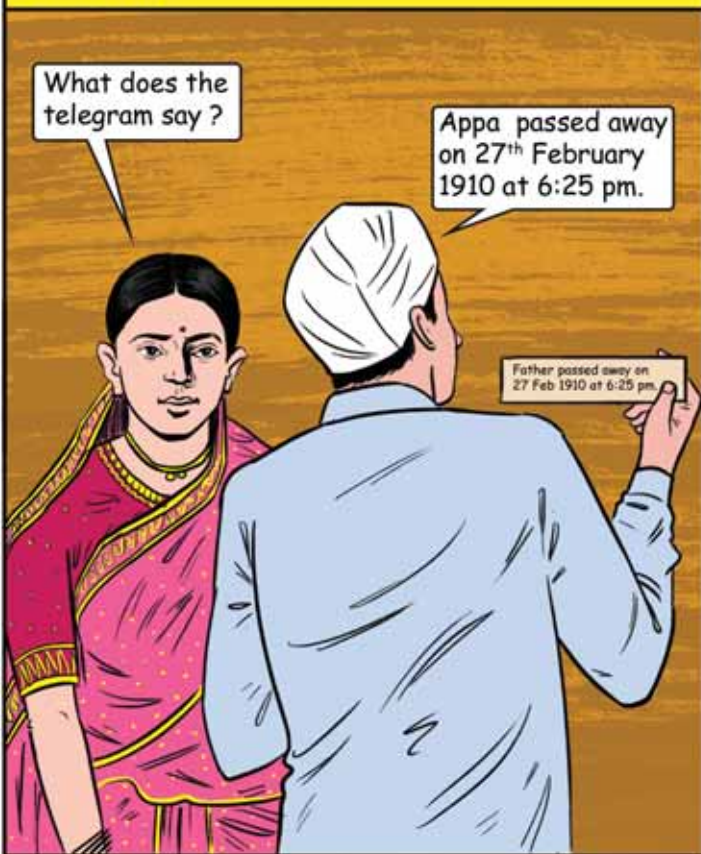
Raman's excitement was short-lived. He was soon frustrated for not being able to conduct the kind of experiments he would have liked to in a well-equipped lab.



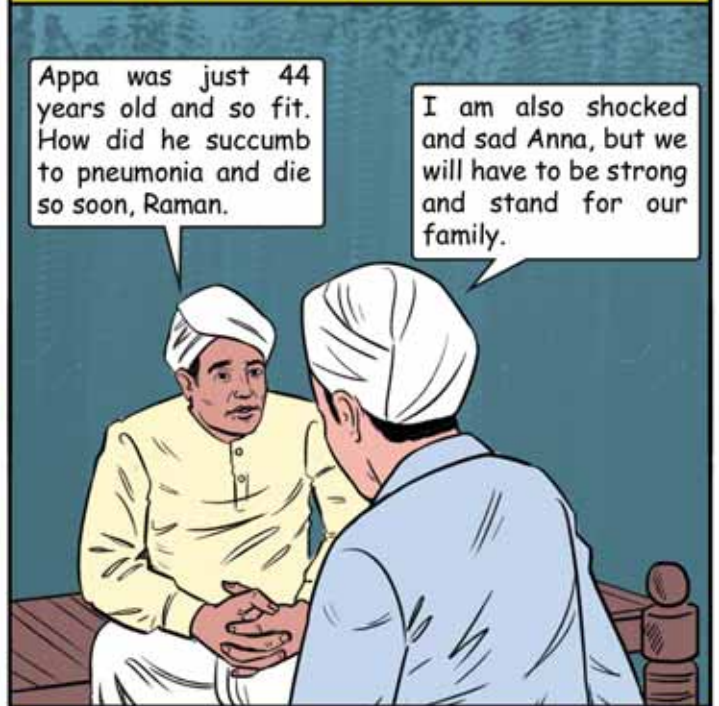
You need to relax. You have been restless for several days now, neither sleeping nor eating.

I can't help but feel miserable about not being able to do the work I want to.

To add to their sorrows, the duo received a very disturbing telegram from Raman's home stating Appa passed away.

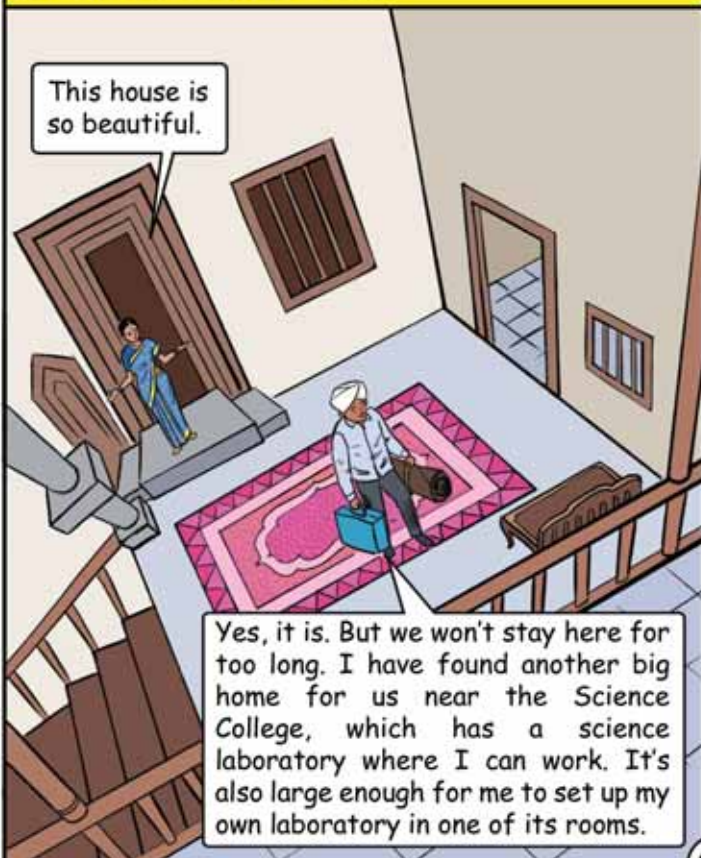


Due to the strict job handover protocol that a Currency Officer had to follow, it took Raman and Lokam 11 days to finally get to their Vizagapatam home.



Appa's sudden death kept Raman away from laboratory. It was then that he realised not to waste any more time as he had already taken six-months leave.

At the end of Raman's six-month leave, Raman was transferred to Nagpur as Deputy Accountant General and was allotted a lavish home.



Raman got busy again with his experiments and Lokam got involved in running the household. But their stay in this home was even shorter than expected.



They spent six weeks living in tents, without any running water. But their ordeal in Nagpur ended soon.

Raman and Lokam's difficulties ended soon as Raman was transferred back to Calcutta.

I have a great news, Lokam. I am being transferred back to Calcutta.

That's great ! Does it mean that you are being promoted ?

I am not being promoted. But who cares ? I am happy going back to Calcutta and focus on my experiments.

Raman was also interested in Astronomy. In Calcutta, he got a chance to work on the subject. He also wrote several papers on Astronomy. But he chose to focus more on his lab experiments.

Raman, are you losing interest in Astronomy?

No, but the lack of a good telescope poses challenges to my ambitious ideas.

Raman's research papers were appreciated by scholars across the world and he was becoming a popular lecturer amongst science enthusiasts as well.

I have never seen so many people at the IACS. It's all because of you.

Ashu babu, I am happy that science enthusiasts find my lectures interesting and are willing to hear me on my experiments.

But all was not well with Raman's family. His younger brother Skandan succumbed to an intestinal tuberculosis in October 1914. Losing his third sibling (after Sundaram and Meena) within 7 years (1907 to 1914) shattered Raman and Subramanyam.

Raman, I am extremely sad. The family has lost many members in the last seven years.

Anna, the passing away of Skandan, just 20 years old, is a great loss. He was a bright young man.

Raman seemed to have realised that there was so much to do and so little time to accomplish it. He shifted to a new rented house which was very close to IACS.

Why are we moving house again? And that too from a posh place to the one near the slums?

The new house is very close to IACS, which means I have to spend less time commuting in between the lab and the house and spend more time there.

Oh! that's the reason.

The new rented house shared its wall with the IACS.

Ashu babu, since I am so close to the lab, I want to work in the lab during odd hours at night. I would like to get a door made in the shared wall of the institute and get its key, so that I can walk in and out whenever I want.

Is that the reason you shifted to this house? Ok, it will be done.

Raman and Lokam lived in this house until they moved to Bangalore in 1933.

Back in Calcutta, as the nationalist movement gained momentum, renowned Indian scholars and scientists pushed for a change in the education system as well. Sir Asutosh Mookerjee was one of them. A brilliant scholar and trained in Law, he was appointed as a Judge of the Calcutta High Court by the British. In 1906 he was appointed Vice Chancellor of Calcutta University. He loved science and was watching emergence of Raman as scientist. Asutosh Mookerjee then approached Raman with an offer of Palit Professorship.

Raman, would you like to accept Sir Taraknath Palit Professorship at Calcutta University? But I am afraid the salary (Rs. 600/-) is not as high as your current salary (Rs. 1100/-). Also, you will not get all the Government perks.

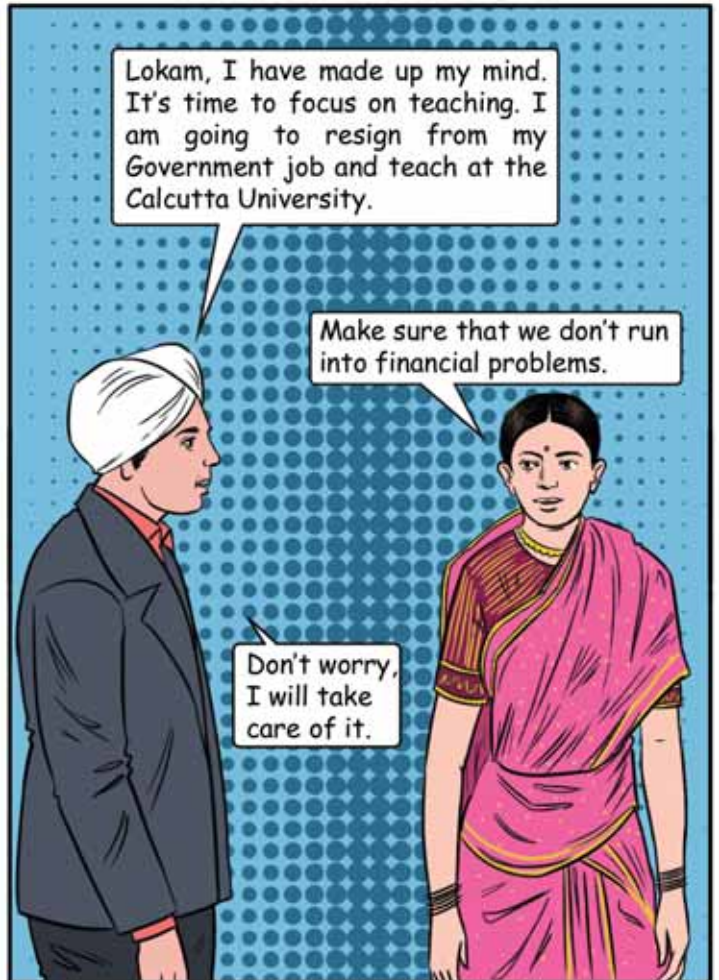
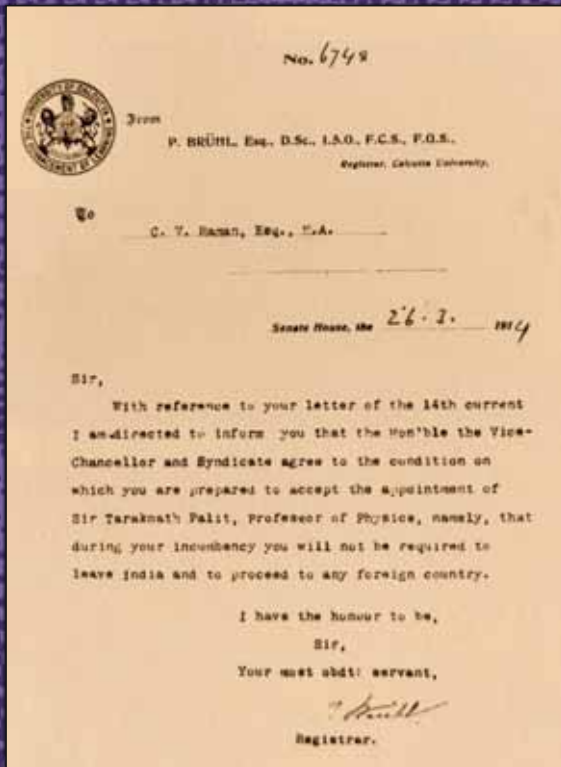
Yes, I love teaching and doing research. Lesser money doesn't bother me.

But one of the conditions of Palit professorship is that the incumbent should have been trained abroad.

It's a strange condition. Instead, I feel confident to train foreigners in India.

Later, ways were found to exempt Raman from this condition and after that he took up the appointment.

On 27th March 1914, Sir Asutosh Mookerjee showed the letter of exemption at the foundation-stone-laying ceremony of the University College of Science (UCS), located at 92 Upper Circular Road in Calcutta.

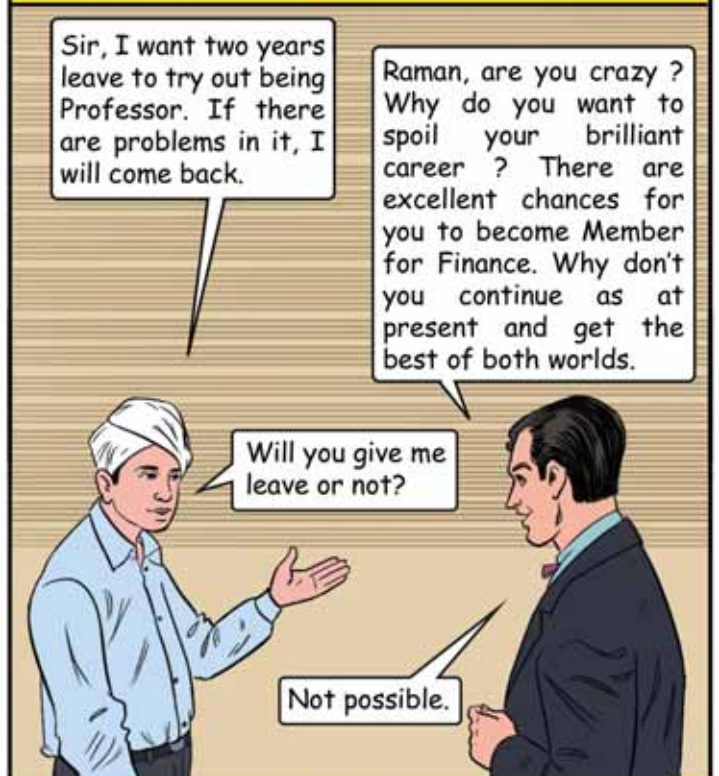


Raman wanted to resign from Government post of DAG (Deputy Account General) and take up Palit Professorship immediately. But Sir Asutosh Mookerjee requested him to wait till the funding situation at the University becomes clear.



Raman continued to work in the Government and simultaneously continued his research work on sound and vibration. He published 13 papers on these subjects in Indian and English journals.

Meanwhile, Raman asked the Government to give him long leave so that he could try out being a Professor. But his superior denied the leave.



Raman resigned from his government post and joined as Palit professor.

Raman joined as Palit Professor of Physics in July 1917, with the right to use the laboratories at both the UCS and the IACS.

First things first Prof. let's rearrange the labs at UCS and get that expert mechanic from another department / institute to work with us.

Prof. Raman, please forgive me, but we cannot do that as it would annoy other heads.

We need to do what it takes to get the best work done.

Raman was fully focussed on his teaching. He was an inspiring teacher from day one. Raman's teaching attracted research students such as K.R. Ramanathan, K.S. Krishnan and S. Bhagavantam.

Sir, do we have a class today?

Of course, we do have.

But all others have gone out to participate in the non-cooperation movement.

I think we should utilise our maximum time for learning. In fact, we should have a longer lecture today.

While Raman was getting comfortable in his new role as a professor, he lost yet another sibling. His 28-year-old sister, Mangalam, died of the flu pandemic in 1918, leaving behind her six children.

Raman's family tragedies further pushed him away from social life. He started spending maximum time in the lab and at UCS, teaching students.

Sir, it's late. You should go home.

Ashu Babu, due to recent tragedy, the family at home is in a low mood. I rather spend time working on my experiments. Besides, I have to prepare my proposals for the University Senate.

Raman was later made a member of the University Senate, and his focus was on undergraduate studies.

I propose we start more courses in psychology and anthropology as we Indians are good at these subjects. We must do away with a minimum age for the entrance exams and let students study in regional languages and not just in English. I also propose for mandatory retirement.

Prof. Raman, these suggestions are good. But I do not approve the proposal of mandatory retirement.

History is proof that productivity declines post 50 years of age, even in scientists.

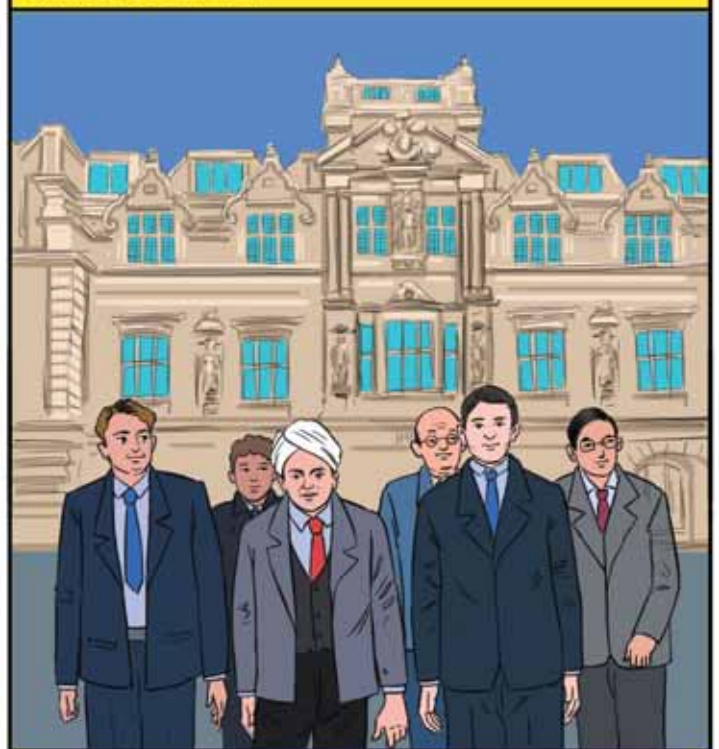
A lot of us here don't agree with your views.

Not many people liked Raman's ways of doing things.

In 1921, when Amrita Lal Sircar died, Raman was elected to take his place as Honorary Secretary of IACS. In May 1921, Raman went to England for attending the University Congress from 5th-8th July, 1921 at the Oxford University. This was his first trip abroad. He was happy as well as worried because Lokam was on family way.

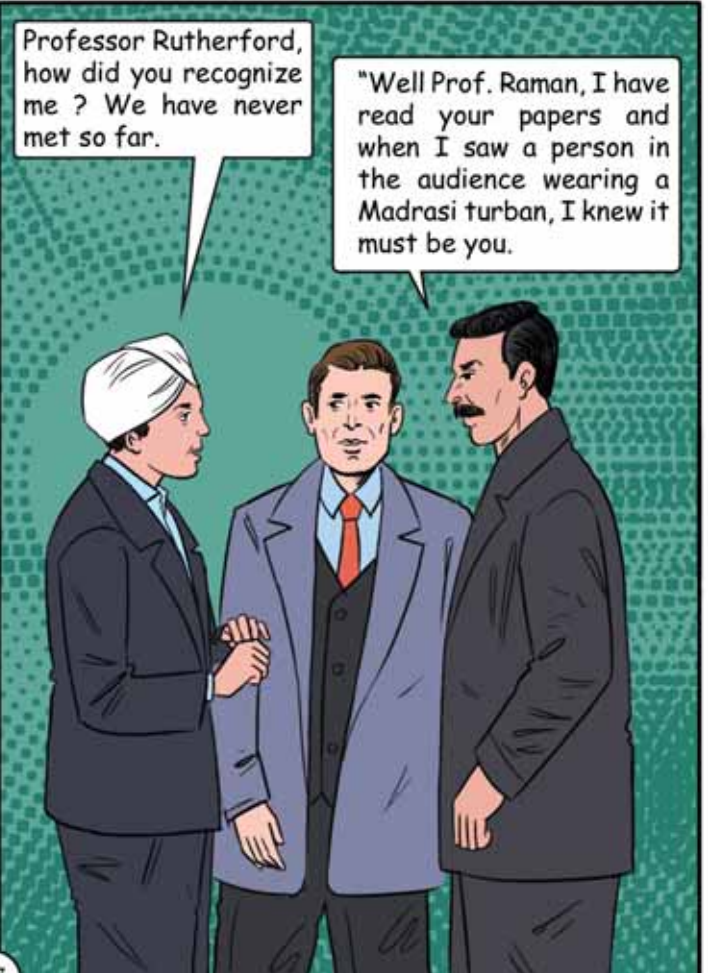
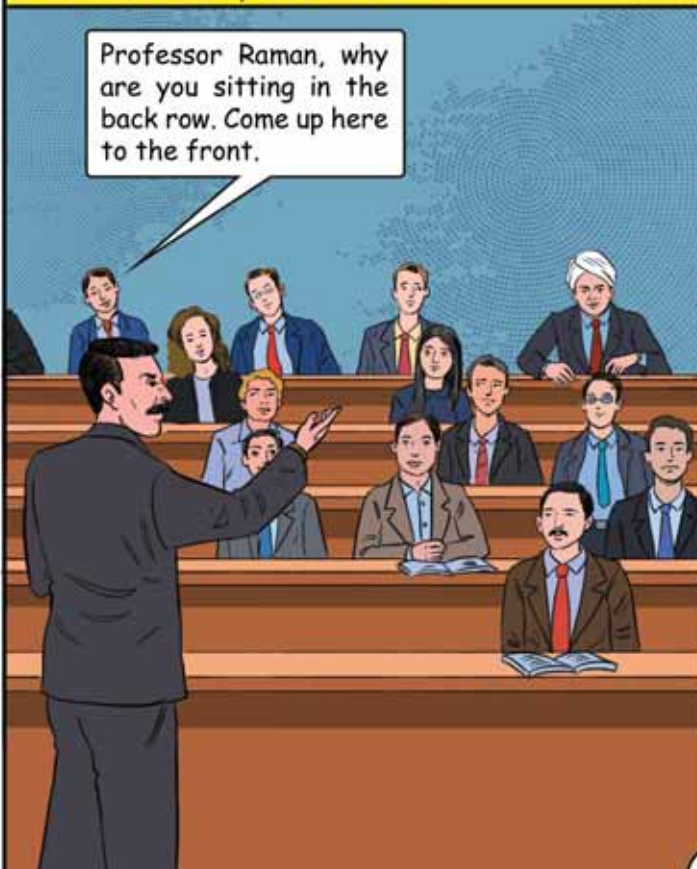


Raman got an opportunity to meet face to face many eminent scientists.

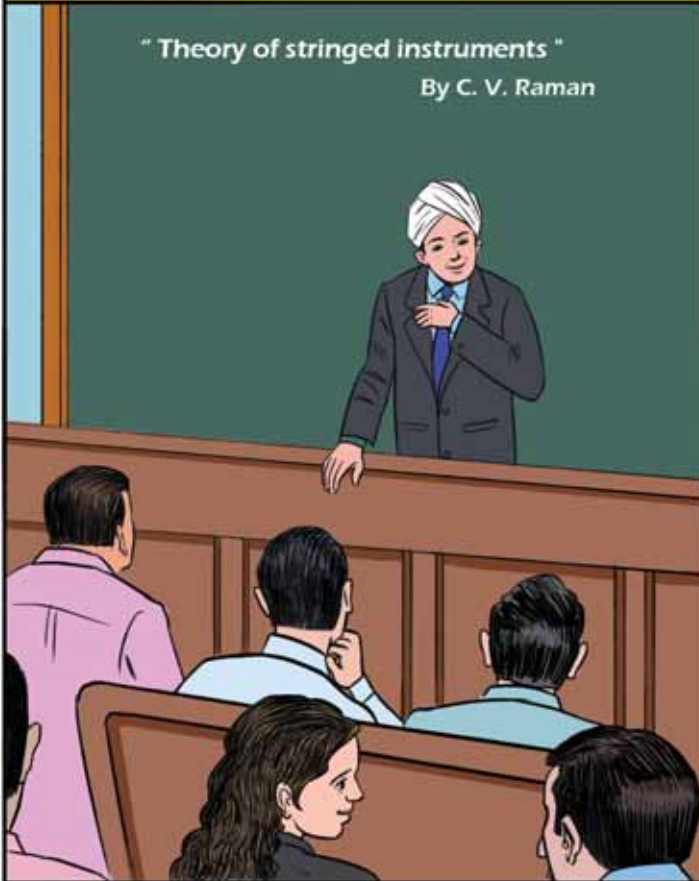


He also got a chance to do some research in England. This included an investigation of the acoustic properties of the central gallery in the St. Paul's Cathedral in London.

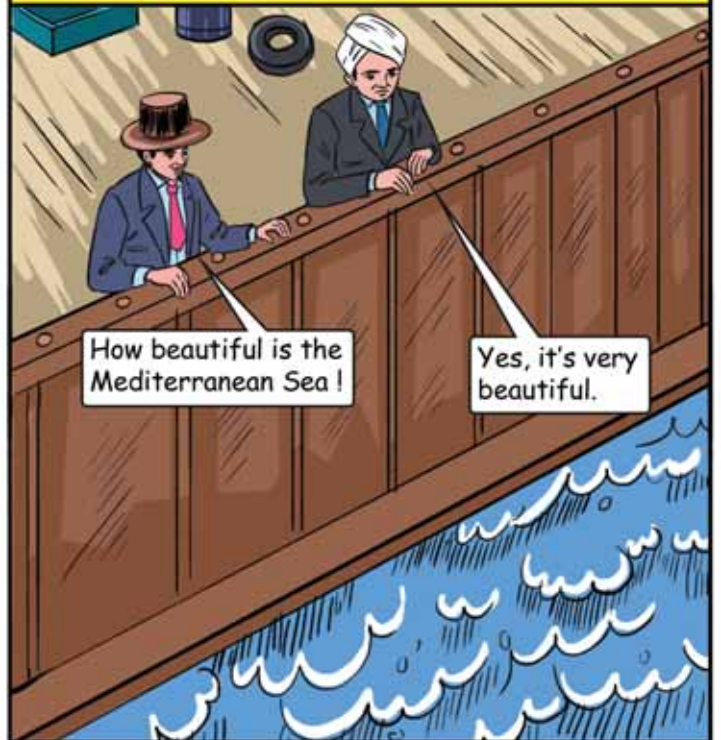
From Oxford, Raman went to London to do more research work. Raman attended a lecture of Lord Rutherford at Royal Institution.



Raman gave a lecture on "Theory of Stringed instruments" at Royal Society of London.



Raman spent nearly two months in England and returned to India in September. While Raman thought of many great ideas in England, his sea journey back home proved to be more fruitful.

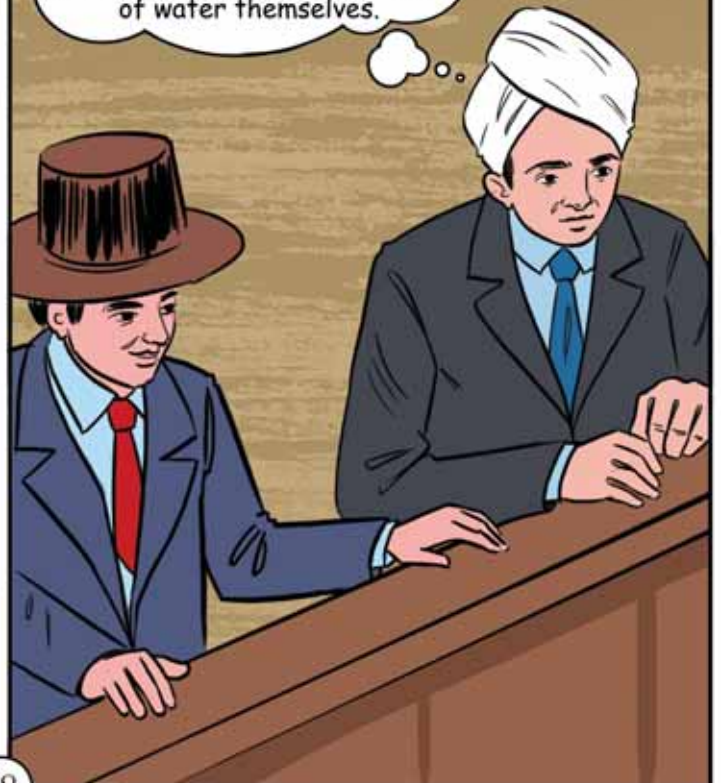


Sea and sky had always caught Raman's imagination, living in Waltair and in Madras.

But why is the sea blue?
According to Lord Rayleigh, it's because the sea reflects the colour of the blue sky. But I don't think it's that simple.



I think the sea is blue because of the diffraction effect caused by the passage of light through water. The diffracting particles may be the molecules of water themselves.



While others were enjoying during ship journey, Raman was busy doing experiment on the "Colour of the Sea".



At night Raman used to draw conclusions and write his manuscript.

On 18th September, 1921 when the ship reached at the Aden port (Yemen), all other passengers got out and went for shopping and sight-seeing. Raman instead rushed to the nearest post office to mail a paper* to journal "Nature" which contained his observations made during the sea journey.



Raman completed yet another paper during the remaining journey which he mailed to "Nature" after reaching Bombay. (*Smoky quartz. Nature, 108[1921],8)

Raman worked for weeks on a more detailed experimental verification after reaching Calcutta.

Sir, you worked on this paper* for several weeks and the result is just one page publication!

My dear, this is a work in progress and it is important to keep your colleagues worldwide updated about your progress.



On October 15th, 1921, Raman mailed another paper to Nature proving that the scattering power of water is about 160 times that of air. After a month of more experiments, he sent another detailed paper* in Mid-November. It was published in the Proceedings of the Royal Society in 1922.

(*On the molecular scattering of light in water and the colours of the sea. Proc. R. Soc. Lond. A, 101, 64-80)

In November 1921, Raman and Lokam were blessed with their first son, Chandrasekhar.

Lokam, I am delighted that we are blessed with a baby. Should we call him "Raja"?

"Raja", sounds good.



After becoming a Palit professor, Raman had started spending all his time between the UCS and IACS. He overworked in a confined space for long hours and this brought a health crisis such as breathing trouble. Apart from medicines, the doctor prescribed a two hour walk every single day in open air. Lokam accompanied Raman for his walks.

I have realised physical activity such as long walk is important for good health.



I am glad that you are finally following doctor's advice and taking care of your health.

In 1922, Raman wrote a monograph on the molecular scattering of light in water and the colour of the sea, dedicated to Sir Asutosh Mookerjee. It was published by Calcutta University.

ON THE MOLECULAR SCATTERING OF LIGHT IN WATER AND THE COLOUR OF THE SEA

He intuitively concluded that the interaction of the photon with a molecule must reveal itself by a change of colour.

*Dedicated to Sir Asutosh Mookerjee.

During the next four years, he assigned many of his students to follow up on the monograph, with quantitative measurements of light scattering in liquids and transparent crystals.

Ramanathan, I heard you are going to Rangoon?

Yes, sir

Please collect water from different areas of the sea for our experiments on light scattering.

Sure, sir.



In 1923, after Ramanathan was back in Calcutta, he was the first to notice the change of colour on scattering. It was called fluorescence. Other researchers of the Association repeatedly saw feeble light at a different frequency and they all interpreted it as due to fluorescence.

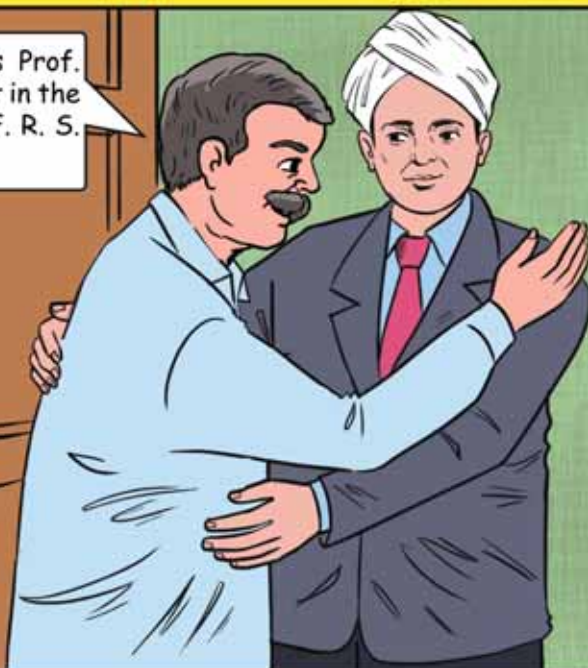
Wow! Is that fluorescence* I see? I must report this to Raman sir immediately.



[* Emission of electromagnetic radiation (usually in visible range) caused by excitation of atoms/molecules in a material.]

The Royal Society was founded on 28th November 1660 at Gresham College, London. From 1663 it was known as Royal Society of London for improving natural knowledge. Sir Isaac Newton served as its President from 1703 until his death in 1727. Being elected a Fellow of The Royal Society (F.R.S.) was considered to be prestigious. Having the right to append the three letters- F.R.S.- to one's name meant the ultimate mark of scientific distinction. Raman was elected as F.R.S. at a very young age of thirty-six. Sir Asutosh Mookerjee congratulated Raman on this occasion.

This is a great news Prof. Raman. Every scientist in the world wants to be a F. R. S. and you are one now.

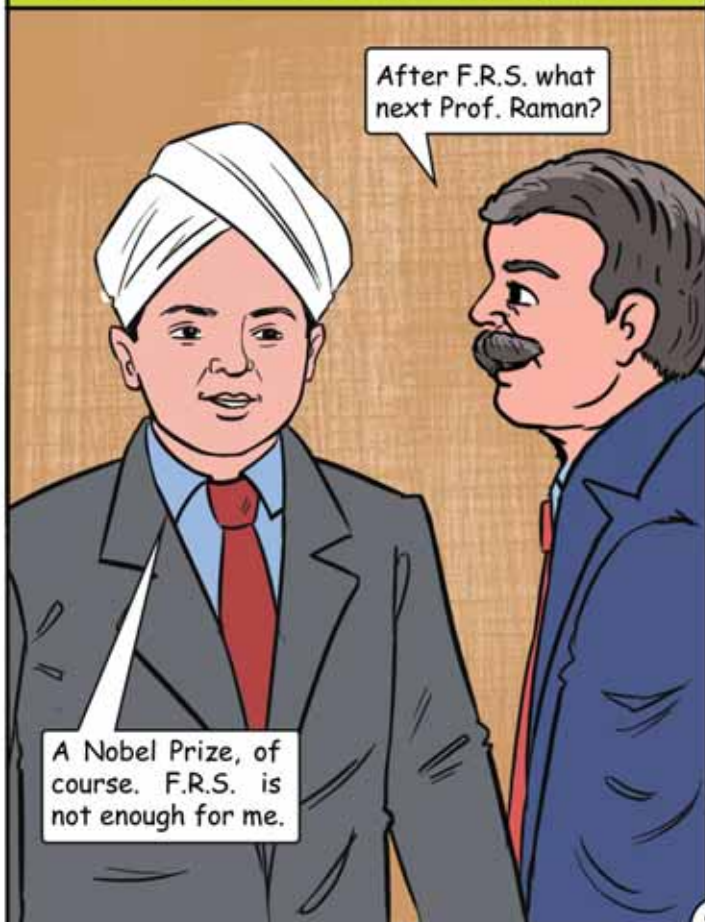


Thank you Sir, I am grateful to GT Walker and George C Simpson for nominating me.

Only F.R.S. could nominate a fellow scientist for F.R.S. Raman nominated a couple of Indian scientists to the Royal Society including K.S. Krishnan (1940), Homi Bhabha (1941) and S. Chandrashekhhar (1944).

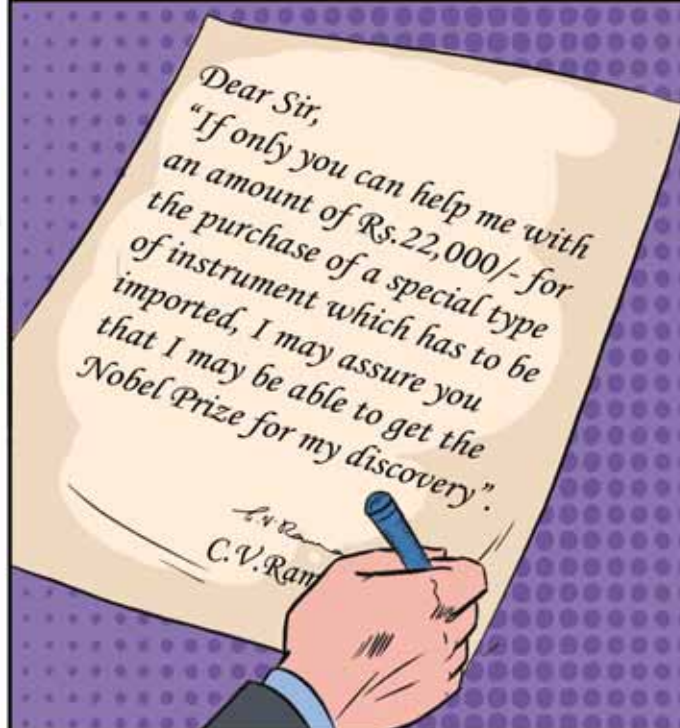
A party was organised to felicitate Raman by Sir Asutosh.

After F.R.S. what next Prof. Raman?



A Nobel Prize, of course. F.R.S. is not enough for me.

Raman's ambition became clear to all his colleagues and family. He wanted to win a Nobel for India. In 1925, he wrote a letter to G.D. Birla for a donation of Rs. 22,000/- to buy a spectrograph.



Mr. Birla replied to C.V. Raman's letter immediately and enclosed a cheque of Rs. 22,000/-.

Meanwhile, Ramanathan came with an observation and shared it with Raman.

Sir, I think the fluorescence is caused by the impurities in the liquid.

That's not possible as the band exhibits polarisation. But let's keep working on it and we will find an answer soon.



In 1927, American physicist A.H. Compton won the Nobel Prize for finding out what happens when X-rays of a known frequency hit a graphite block.

Compton concludes that X-rays enter the graphite at one wavelength and leave at a longer wavelength, as they have transferred both momentum and kinetic energy to an electron. Basically, matter absorbs radiant energy.



This discovery gave impetus to Raman's experiment. Raman strongly believed we must have an equivalent phenomenon in the visible region of spectrum.

Even as new ideas were taking shape in Raman's mind, S. Venkateshwaran, a researcher under Raman, studying light scattering from glycerine reported that "the colour of sunlight scattered in a highly purified sample of glycerine was a brilliant green, instead of the usual blue". Raman was now tremendously excited. On hearing this news, Raman got delighted and called Krishnan to join experimental work.

Look here Krishnan, if energy exchange is true for X-rays, it must be true for visible light also. There must be an optical analogue to the Compton effect. We must pursue it and we are on the right line. It must and shall be found. The Nobel Prize must be won.



Ever since he returned from England (1921) Raman was working on this problem.

Events started to move really fast afterwards. K.S. Krishnan and Raman worked for long hours at the lab. On 5th February 1928, Krishnan devoted his full time to study fluorescence and made few important observations.

Sir, I observed that all pure liquids are showing a fairly intense fluorescence in the visible region and they are strongly polarised.

I can't believe this. It is very exciting and it is an amazing result. How come we missed this significant observation five years ago.



Later, on 7th February 1928, post dinner, Raman and Krishnan discussed the observations.

Krishnan, what you have observed in the morning must be Kramers - Heisenberg effect that we have been looking for all these days.

Can we call it a modified scattering, Sir?

Yes, I agree.

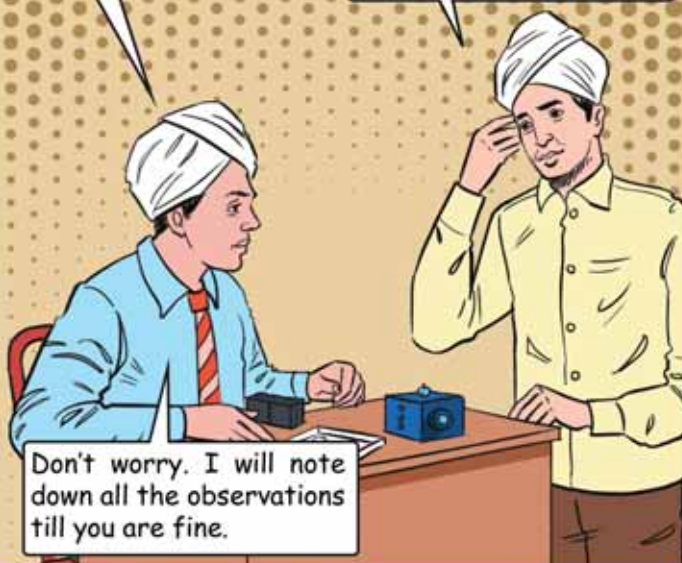


On 9th February 1928 morning, the long telescope was setup and preliminary arrangements were made for observing the effects with vapours. But Raman left for the college for his lecture. Raman came back from college at 3 pm and made observations. He ran about the place showing that it was a first rate discovery.

On 16th February 1928, pentane vapours at high temperature were studied and it clearly showed polarisation in the modified scattering. A note* was sent to "Nature" on the subject under the title "A new type of secondary radiation".

Krishnan, I confirm the polarisation of fluorescence in pentane vapours.

Sir, I am having some trouble with my left eye. Can you note down further observations?



Don't worry. I will note down all the observations till you are fine.

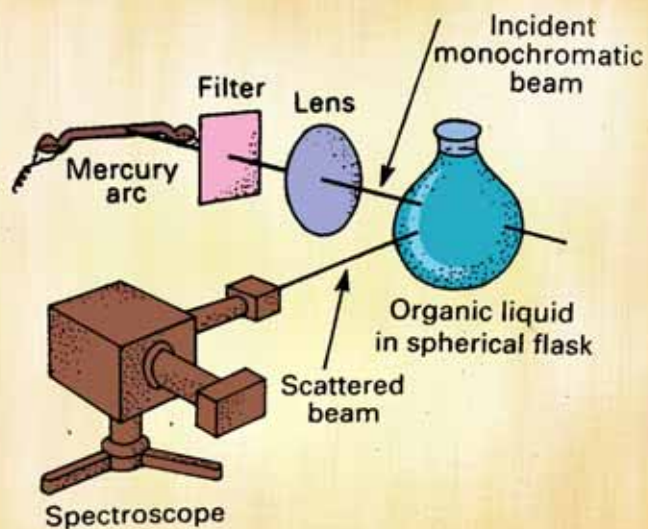
[*NATURE (31st, March 1928) Vol. 121. Page 501-502.]

On 28th February 1928, Raman and Krishnan performed the experiment at lab which clearly brought out that radiation of frequency λ changes to a different frequency λ' . The incident radiation was made nearly monochromatic by using the combination of the usual blue-violet filter and a piece of uranium glass. The scattered light was examined with a spectroscope.



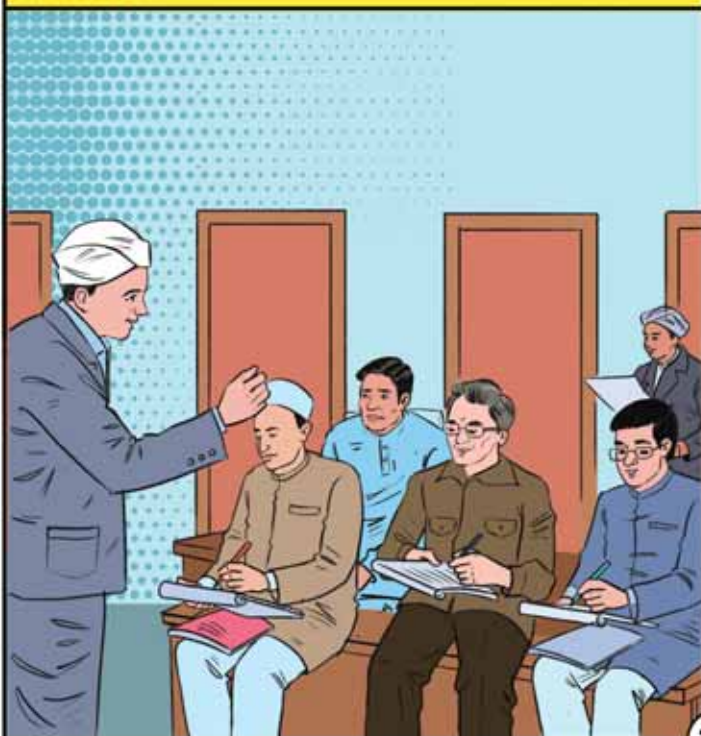
Raman and Krishnan observed a strong band corresponding to the incident light and another band somewhat feeble but clearly visible and well separated from the band corresponding to that associated with the incident radiation.

Later that day, Ashu Babu setup a mercury arc, a light source known for its sharp monochromatic lines. Using a filter in the incident light which cuts off all the visible light longer than the indigo 4358 Å line, the direct vision spectroscope showed not one but two sharp lines in the blue-green region.

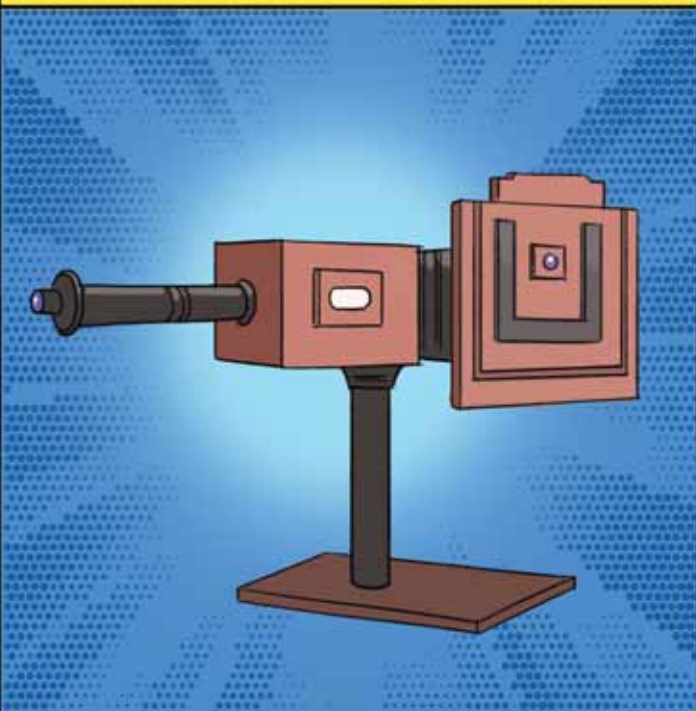


Raman used the above experimental setup to photograph Raman shifts in several liquids.

Raman called a press conference and announced his discovery. Two weeks later, on 16th March, Raman gave a detailed lecture on his discovery at the South India Science Association at Bangalore. There he showed for the first time, slides of the frequency shift produced by Raman Scattering. (subsequently called Raman effect).



The shift in frequency of the new line (from the incident one) was identified with the change in the energy of the vibrational state of the molecule.



Raman Effect allowed for the first time to measure vibrational frequency of homo diatomic molecules such as H_2 , O_2 and N_2 .

Meanwhile, Prof. R.W. Wood, Distinguished Optical Physicist of Johns Hopkins University, USA wrote in Journal Nature about Raman's discovery and it read as

Prof. Raman's surprising discovery

I have verified his discovery in detail. Raman's discovery thus makes it possible to investigate remote infrared regions hitherto little explored.

It appears to me that this very beautiful discovery which resulted from Raman's long and patient study is the most convincing proof of the quantum theory of light.

Soon Raman's discovery became popular in India.

The discovery was not the result of an accident, but was the culmination of seven years of systematic and sustained work carried out with devotion by Raman Sir.

The entire discovery happened with the simple apparatus of a mercury lamp, a flask of benzene and a direct-vision spectroscope and Raman Sir had spent hardly Rs. 200/-* for the equipment.



*The total cost of the equipment was Rs. 7630/-. [Ref.- "How costly was Raman's Equipment for the Discovery of Raman Effect?" published in Indian Journal of History of Science, 53(4) (2018) T68-T73.]

Raman's discovery was so unbelievable that many foreign scientists started verifying Raman's discovery and it became more popular in the western world.

Look, there is new research work published by Prof. Raman.



I have already gone through this, as no two compounds have the same Raman spectrum, and since the intensity of a Raman line of a substance is proportional to its concentration, Raman spectroscopy can be used extensively in qualitative and quantitative chemical analyses.

Scholars from across the world hailed Raman's discovery. The Italian Society of Science awarded Raman "The Matteucci Medal" for the year 1928. The University of Freiburg conferred an honorary Doctorate degree on him, in 1929. He was also conferred with the title of "Knighthood" in 1929 and respectfully called "Sir C.V. Raman" and Mrs. Lokasundari Raman as "Lady Raman".

The Italian Society of Science



On 4th October 1928, a great physicist from Germany, Arnold Sommerfeld visited IACS, Calcutta. He visited Raman's laboratory and saw a demonstration of this unbelievable new discovery.

I am impressed with your experimental results and it's explanations.

Thank you so much.

Raman was proposed for the Nobel Prize for Physics in 1929 by Niels Bohr and Charles Fabry. The 1929 Nobel Prize for Physics was awarded to Louis de Broglie.

On 18th May 1929, Raman's second son Radhakrishnan was born.

My joy of success has multiplied with the birth of Radhakrishnan.

In 1930, Eugene Bloch, Niels Bohr, Louis de Broglie, Maurice de Broglie, Orest Khvolson, Jean Perrin, Richard Pfeiffer, Lord Rutherford, Johannes Stark and Charles Wilson proposed Raman for Nobel Prize. The Physical Society of Switzerland gave him an honorary membership and The Royal Society awarded him with the Hughes Medal in 1930.

The meetings of the Nobel Committee are held in the highest secrecy. The awards were announced in November (now in October) and prizes given in December. Raman was sure of getting the Nobel prize in 1930.

I should book tickets to reach Stockholm by December first week.

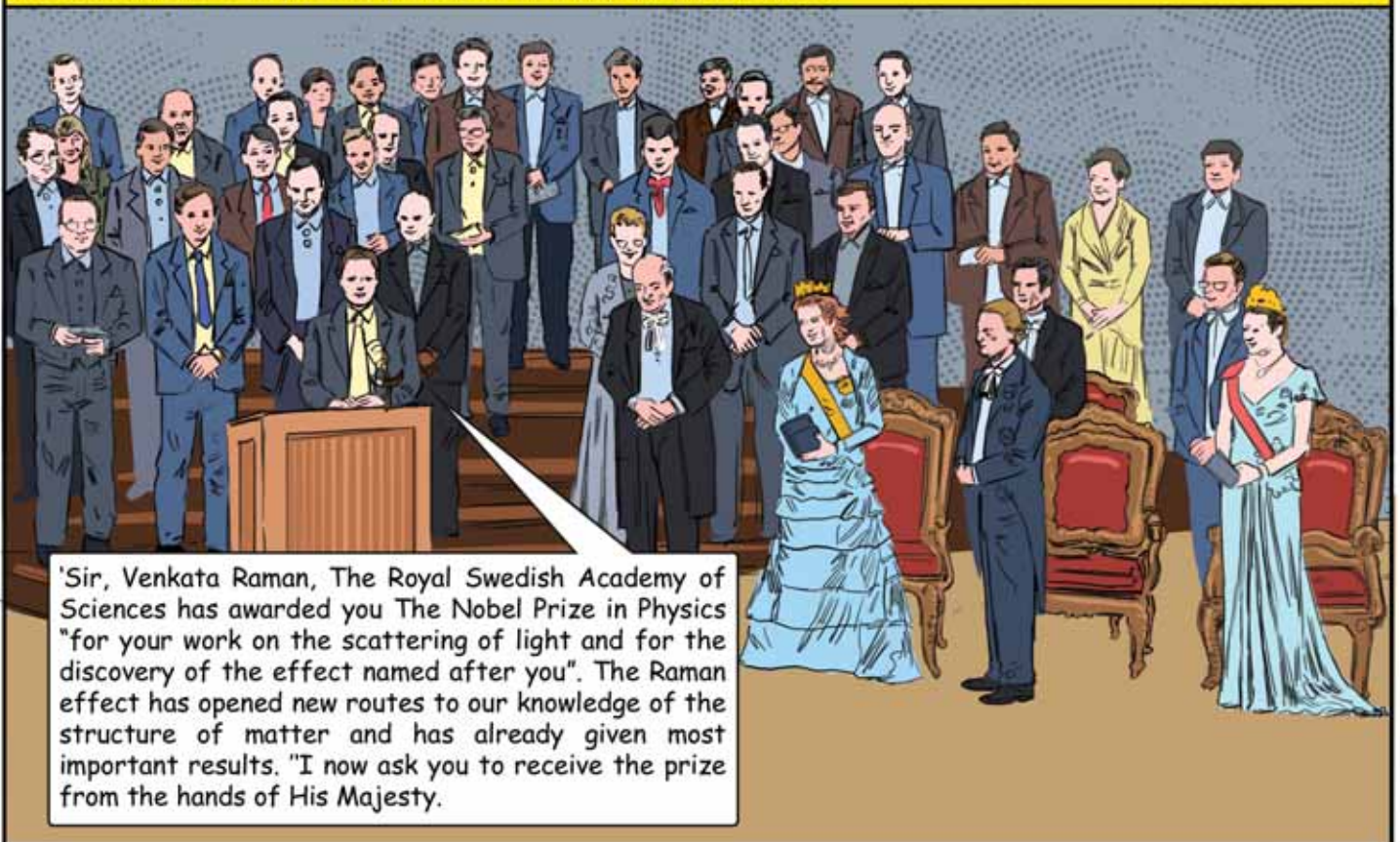
Raman and Lokam were amazed and delighted to see the overall ambience of the concert hall.

You had mentioned there will be who's who of the scientific world ! This, indeed, is a very special occasion. I am feeling extremely proud of you.

Thank you, Lokam. It's truly a proud moment for us as well as for science done in the country.

Raman booked two tickets (for him and Lokam) in July, 1930. The announcement of 1930 prize was made on 13th November (early morning of 14th November in India). Raman sailed from Bombay on 20th November, 1930 and he barely made it by arriving in Stockholm on 9th December.

The award of the Nobel Prizes took place on the 10th December 1930 between 4 and 7 p.m. at the concert hall of Stockholm, decorated with flowers and flags, and it was filled with more than 4000 people. The King and Queen of Sweden and the Royal family occupied the seats in the first row.



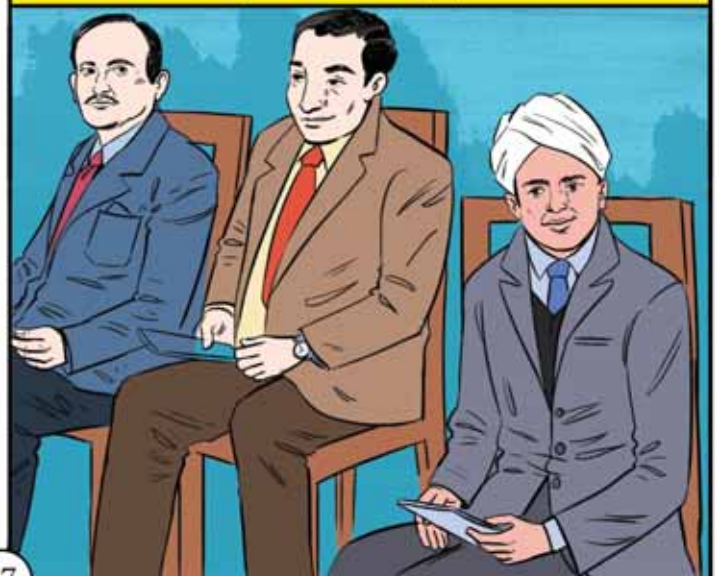
'Sir, Venkata Raman, The Royal Swedish Academy of Sciences has awarded you The Nobel Prize in Physics "for your work on the scattering of light and for the discovery of the effect named after you". The Raman effect has opened new routes to our knowledge of the structure of matter and has already given most important results. "I now ask you to receive the prize from the hands of His Majesty.

Many, many congratulations, Dr. Raman.

Thank you Sir, I had dreamt of winning this prestigious award for my country and now that dream has come true.



The mixed feeling of Raman at the time of receiving the Nobel Prize are best described in his own words. "When I sat down in that hall and I saw the sea of the western faces surrounding me, and I, the only Indian, in my turban and closed coat, it dawned on me that I was really representing my people and my country. I felt truly humble when I received the Prize from King Gustav. Then I turned around and saw the Union Jack under which I had been sitting and I realized that my poor country, India, did not even have a flag of her own - and it was this that triggered off my complete breakdown leading to tears in my eyes".

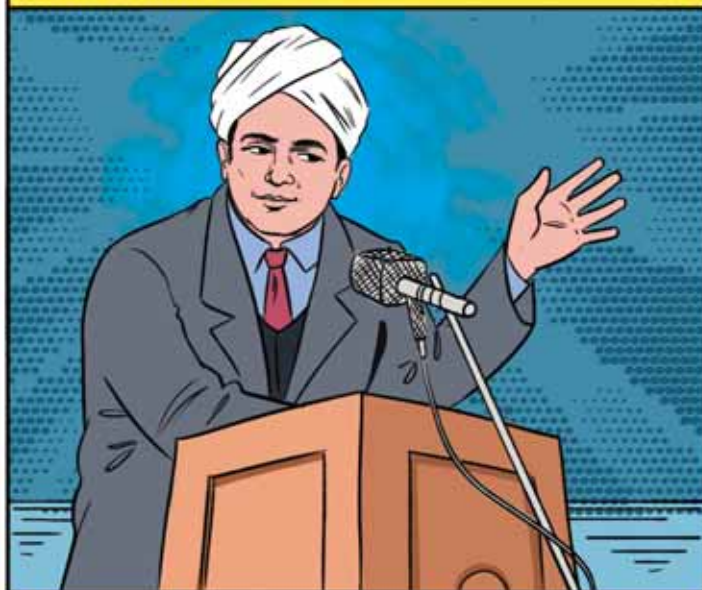


Lokam, in her diary, mentioned that during the Nobel Prize ceremony, Raman spoke about Gautam Buddha in his acceptance speech and also mentioned the congratulatory note he had received from a friend who was jailed.



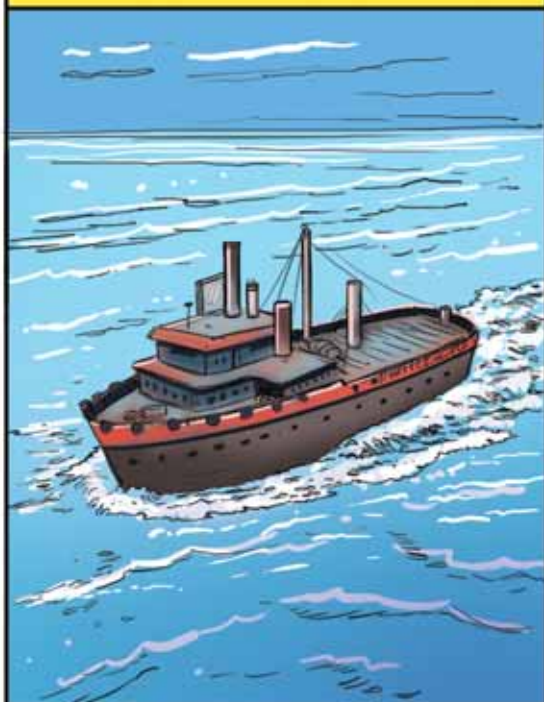
After a few years, Raman revealed that friend was none other than Mahatma Gandhi.

On 11th December 1930, the Nobel lectures were delivered at University of Stockholm. Each Nobel prize winner spoke about his own work. Raman, in his lecture, traced the stages of the discovery from his first Voyage on the Mediterranean in 1921. He mentioned the name of all of his associates who had worked with him.



Later in the evening, the King and Queen hosted reception for the Nobel Laureates. Lokam and Raman also met the grandson of Tolstoy who kindly took them to various places of interest in Stockholm.

Raman and Lokam visited various places in Europe such as Oslo, Goteborg, Copenhagen, Hamburg, Geneva, Munich, Paris, Glasgow, London, Milan, Florence etc. They arrived at Bombay port on 19th February, 1931. Raman, was destined to play more significant role in shaping the future of Indian Science.



During this time, Sir Martin Forster was due to retire from Directorship of Indian Institute of Science (IISc.) [Locally Known as Tata Institute in Bangalore]. The Tatas informally approached the Royal Society for some suggestions concerning a successor, indicating that, if possible, they would prefer an Indian. Lord Rutherford, who was then the President of the Royal Society was consulted and he said "It is no longer necessary to search for Directors in England, when India has as distinguished a candidate as Prof. C.V.Raman." The Institute Council recommended to the Viceroy that Prof. Raman be appointed Director of IISc.

I am surprised at the IISc. offer as I had not applied for it.

Are you going to accept it?

I would like to, but I don't want to rush into it. What if I don't like the scientific environment at IISc.?

Raman thought of applying for a long leave from IACS while he spends some time at IISc. But things didn't go as he wanted them to.

What is bothering you?

I had hoped that the IACS would approve my leave, but they didn't. Plus, there have been newspaper reports and complaints, alleging me of supporting South Indian scholars over others and giving too much importance to Physics over other subjects.

But, that's not true.

I know that, but there is no point in fighting with the system.

It is believed that these allegations against Raman were a result of jealousy and internal politics by the scientists who were not pleased with Raman's success. He decided to move to Bangalore. While he was about to leave Calcutta, Dr. Fermor (Director of Geological Survey of India) said.....

"Calcutta's loss would be Bangalore's gain. At present Calcutta may be regarded as a centre of scientific research in India but with the transference to Bangalore of one of our leading investigators, she will have to guard her laurels."

Raman left Calcutta on 24th March, 1933 by S.S. Halbera ship and arrived at Madras on 28th March. He travelled by car to Bangalore on 30th March, 1933. Raman joined as Director, IISc. on April 1st, 1933.

Raman found the atmosphere at the IISc. dull and lacking in dynamism. He also found the quality of research work to be quite ordinary at IISc. But Raman invigorated the place through his presence, energy and discipline.

We are excited to have you with us. We are very sure that under your leadership, the institute will reach greater heights.

That's my aim, but a lot of restructuring is required to be done.

For consolidating research activities in India, Raman founded Indian Academy of Sciences in 1934. Raman's detractors said that he did this to pre-empt the formation of another Academy which was in the offing (later to become the Indian National Science Academy). Raman believed "How can Indian science prosper under the tutelage of an Academy, which has on its council of 30, about 15, who are Britishers, of whom only two or three are fit enough to be even its Fellows?"



Meanwhile, in 1935, Raman invited his nephew S. Chandrasekhar (who later received Nobel Prize in 1983 for Physics) to take up an Assistant Professorship at IISc.

Dear Chandra,

I will be pleased to appoint you in the grade of Assistant Professor at IISc. I do not wish to make any rash promises but I have a feeling that at the end of your 5-year tenure, you can look forward to a full professorship being created for you.

S. N. Raman

Chandrasekhar declined Raman's offer since it will be viewed as nepotism. Later, in 1944 Raman proposed Chandrasekhar for F.R.S.

Raman's hard work paid off well at IISc. As a result, next year more than hundred research papers were published.

Last year, we published 32 papers. And this year, after you have joined, we have published 148 papers.

That's good to know. But let us not be complacent. I am planning to invite international scientists at IISc for collaboration on latest topics of mutual interest.



Raman was aware of what was going in Europe. Brilliant scientists were running away from Hitler's Germany and were on the lookout for jobs. Raman thought why not bring some of them to India and thereby raise the research standard of India. Max Born (Nobel Laureate in Physics, 1954) was one such scientist whom Raman had written and invited for six months at IISc.



INDIAN INSTITUTE OF SCIENCE,
BANGALORE, INDIA.

POSTAL ADDRESS: HENRIETTA, BANGALORE. TELEGRAMS: "SCIENCE", BANGALORE. AIR MAIL: 5th EDITION.

All letters, packages, etc., should be addressed to the Director.

726/7095

From
Sir C. V. RAMAN, M.A., Ph.D., D.Sc., I.L.D., F.R.S., F.R.I.,
Director.

To
Professor Max Born,
246, Hills Road,
CAMBRIDGE,
(England).

17th January 1935.

Sir,

I have the honour to inform you that the Council of this Institute have authorised me to extend to you an invitation to accept a special appointment as Reader in Theoretical Physics at this Institute for a period of six months from the 1st October, 1935, on an honorarium of Rs. 10,000/- which will be inclusive of all expenses. Accordingly, I request that you will kindly accept this invitation and join the Institute by the 1st October, 1935.

One of the bungalows at this Institute will be put at your disposal for your residence during this period free of rent.

I have the honour to be,
Sir,
Your most obedient servant,
S. N. Raman
Director.

Max Born discussed this communication with Lord Rutherford at Cambridge.

I have received an offer of professorship from C. V. Raman from Bangalore, India.

This is your chance, go to Bangalore. Anyway, the salary offered by them is better than what you get in Europe.



Max Born along with his wife, Heidi, came to India on 1st October, 1935. He liked Bangalore and IISc. As Director of IISc., Raman mooted a proposal to have Prof. Born as a professor of theoretical physics.



Raman also made an offer to Erwin Schroedinger, but he was too late as Schroedinger had already accepted an offer from Dublin.

At the IISc. Board meeting, Raman discussed the proposal of offering a permanent membership to Max Born. Kenneth Aston, a British Professor of Electrical Engineering, who was one of the Board members objected to this proposal.

I want to propose a permanent membership to the very talented Max Born in the institute.

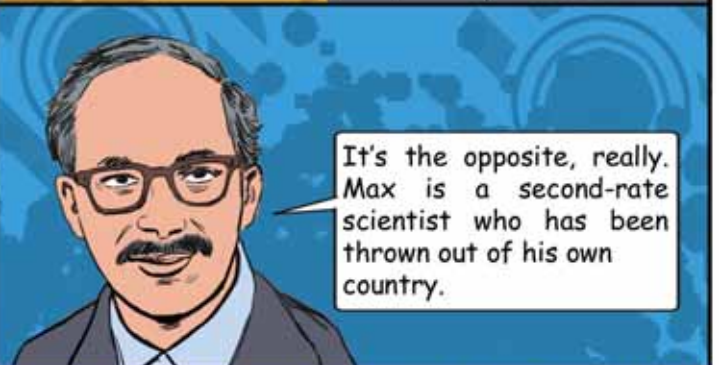
Sorry, Prof. Raman, I do not support your proposal.



Why not, Professor Aston? As one of the leading British professors, you must be well aware that Prof. Born would be a great asset for the institute.



It's the opposite, really. Max is a second-rate scientist who has been thrown out of his own country.

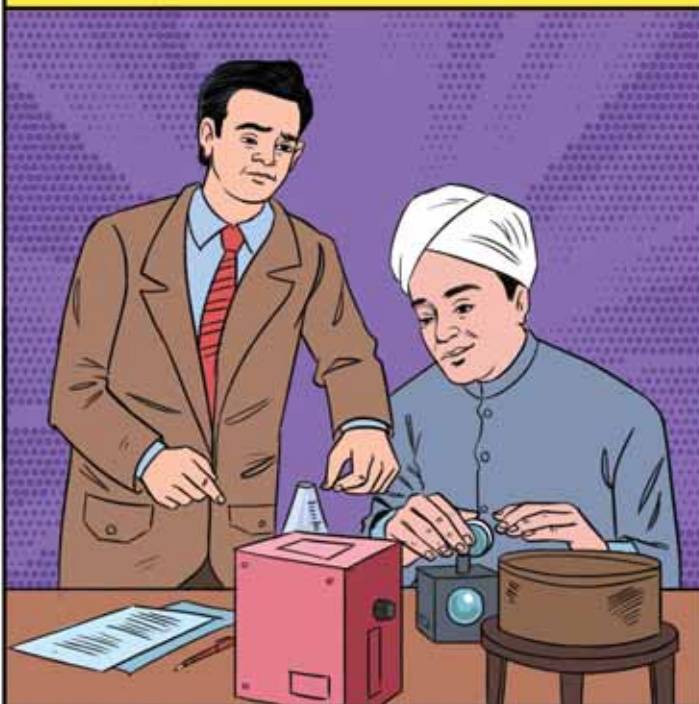


Aston was the same person who had earlier stayed with Born for some time after his arrival from England, till he could find a house. Born was shaken by this behaviour of Aston and later at home he had actually cried while narrating this incident to his wife.

As soon as Raman joined as the Director of IISc., he moved too quickly according to his vision of the Institute. He made many changes and they were rapid just as he did in IACS at Calcutta. But what worked at IACS did not work at IISc. as IACS was dormant whereas IISc. was in deteriorated state and was full of deadwoods. Raman was blamed for faulty administrative decisions, faulty use of funds and general lack of leadership. The invitation of Max Born had aggravated the matter. All these emanated from the petty jealousies and rivalries that were at the base of the movement against Raman's Directorship.



Even as storm clouds gathered, Raman continued with his ground breaking research* with his student Nagendra Nath.



*The applications of Raman-Nath theory grew in leaps and bounds after 1960s, with the advancement in the use of fibre optics for storing digital information and for imaging.

On 20th June, 1936, a committee headed by Sir James Irvine was set up to review Raman's tenure at IISc. The Irvine committee recommended Raman to go. Viceroy Lord Linlithgow was keen that Raman should remain as the Director but the anti-Raman lobby didn't want Raman to continue. Raman was given two humiliating choices.....

- 1) *Step down from the Directorship and stay content with the Professorship of Physics, along with a big salary cut.*
- 2) *Tender resignation with effect from April 1, 1938 on such retiring allowances as entitled according to the rules.*

If Raman declined both the options, he would be suspended.

Raman was keen on continuing his research. So, he accepted the first option and eventually Raman stepped down as Director on 1st June, 1937. It was one more traumatic experience for Raman. Tears shed through his eyes. However, there was a consoling letter from Lord Rutherford which said.....

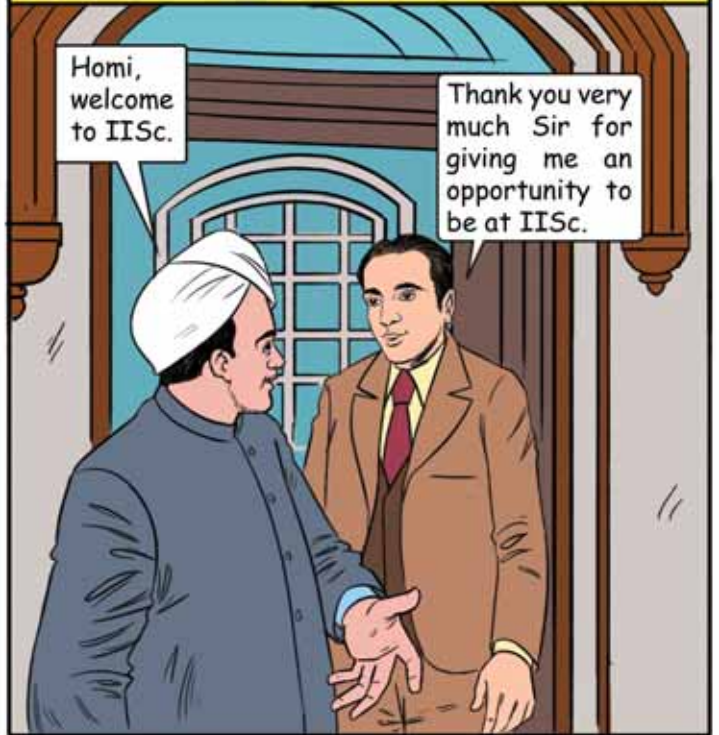
Dear Raman,
Now that the matter is settled,
I trust that you will be able to
carry on with your research work
and let bygones be bygones. It
seems to me highly important
that the staff at Bangalore
should pull together for the good
of the Institute.

[Rutherford]

In 1939, the European scientific scene was disrupted due to onset of World War - II. At that time, Dr. Homi Jehangir Bhabha was on a summer vacation to India. Instead of returning to the Cavendish Laboratory in Cambridge (where he worked) he accepted the post of a reader in Physics Department of IISc., headed by Sir C. V. Raman.

Homi,
welcome
to IISc.

Thank you very
much Sir for
giving me an
opportunity to
be at IISc.



Raman was impressed with Bhabha's dedication and his quality of work. He nominated Bhabha for the Fellowship of Indian Academy of Sciences in 1940 and Fellowship of the Royal Society (London) in 1941.

Hello. Dr. Dirac,
I am thinking of
nominating Dr.
Bhabha for the
Fellowship of the
Royal Society.

That's a good
choice, Dr. Raman.
He surely
deserves it.



The World War also forced Vikram Sarabhai to leave England and return to India. Sir. C. V. Raman wrote to the Cambridge Authorities to allow Vikram to do research work under his guidance for which University of Cambridge readily agreed.



Vikram met Dr. Homi Bhabha in the Physics Department of IISc. This association helped develop a strong bond between Vikram Sarabhai and Homi Bhabha.

When Vikram was working with Raman at IISc., Raman suggested Vikram about considering experimental work on Cosmic Rays.

This is most appropriate technique for our country, perfect the process of making these photographic plates, study cosmic rays at high altitudes using balloons; there may still be a Nobel Prize lurking for you.

Sure Sir, I would like to explore this.



As predicted by Raman, later, British Scientist Cecil Powell pursued the research work on photographic plates and was awarded Nobel Prize for his work in 1950.

The Franklin Institute in Philadelphia used to identify scientist whose great innovation has benefited humanity, helped to advance science, launched new fields of inquiry and deepened our understanding of the universe. For his outstanding work, Raman was awarded "Franklin Medal of Merit" on March 12th, 1941. Previous Franklin Medallists were Marie Curie, Einstein, Millikan, Compton and Hubble. Due to war, Raman's plan to receive this medal in person could not get materialized. Raman later received this Medal in 1942 from Governor of Madras.

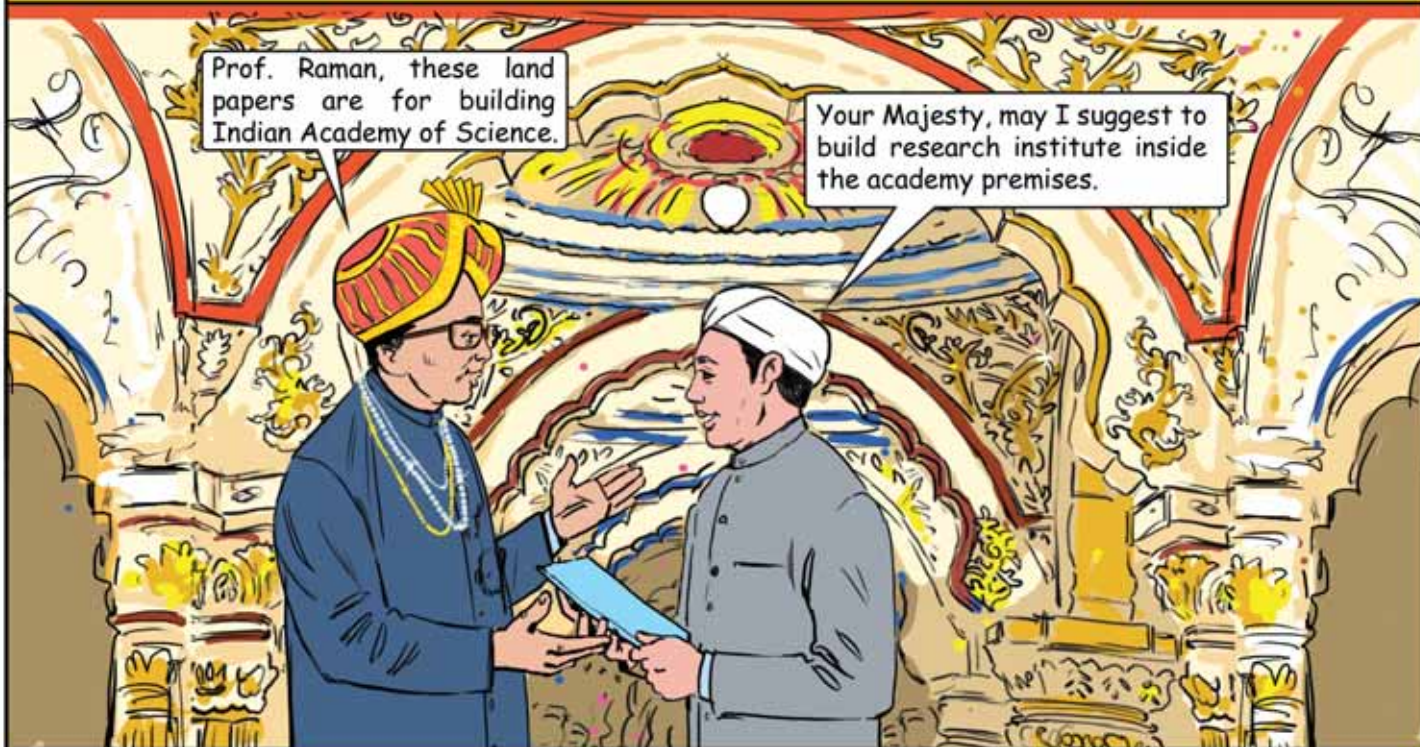


In 1943, with one of his earlier student, Dr. P. Krishnamurthi, Raman started Travancore Chemicals Manufacturing Company. This was an investment that served him well, bringing in a steady annual income.

Back in 1934, the then Maharaja of Mysore, Sri Krishnaraja Wodeyar (the fourth), had gifted Raman ten acres of land near IISc. as a permanent location for Indian Academy of Sciences. Since the promotion of science was the primary objective of the Academy, Raman suggested that a Research Institute be built inside its premises.

Prof. Raman, these land papers are for building Indian Academy of Science.

Your Majesty, may I suggest to build research institute inside the academy premises.



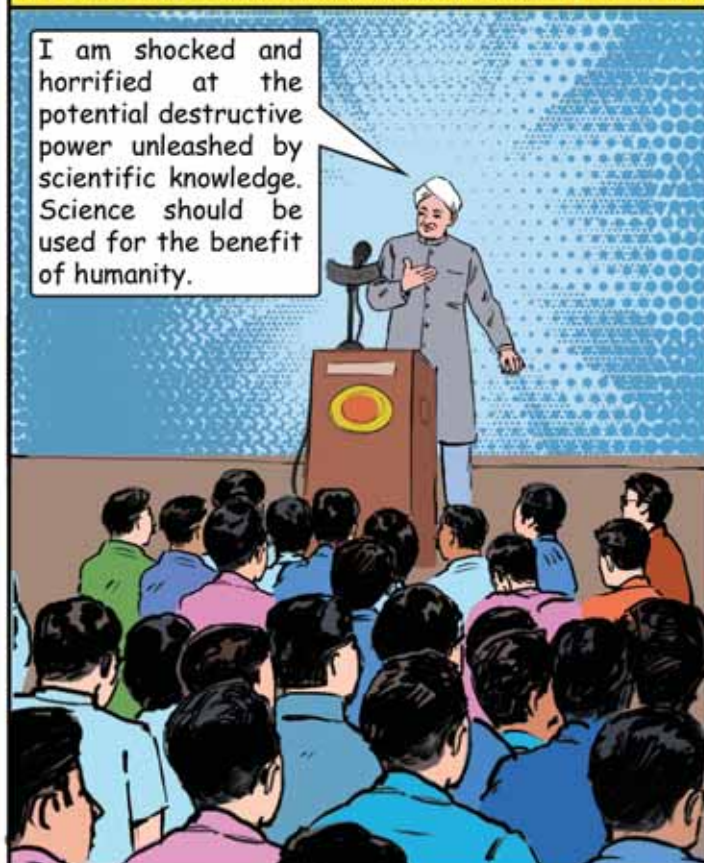
Thus, in February 1943, an agreement was signed for the establishment of the Raman Research Institute (RRI). Subsequently, Raman acquired more land to expand the Institute.

Raman loved collecting crystals, gems, minerals, rocks specimens, shells etc. He also collected Diamonds which he called the prince of solids. He had as many as 310 Diamonds in 1944. He created a museum for his collections which is housed in the Raman Research Institute, Bengalore.



On August 6th and 9th, 1945, two atom bombs (called Little Boy and Fat Man) were dropped over the Japanese city of Hiroshima and Nagasaki respectively.

I am shocked and horrified at the potential destructive power unleashed by scientific knowledge. Science should be used for the benefit of humanity.



In 1948, Raman retired as Professor of Physics from IISc. A grand farewell was arranged. Friends and students from near and far participated.



On 15th August 1954, the Padma and Bharat Ratna awards were announced for the first time. Raman's name was announced for the Bharat Ratna. Indira Gandhi was first to congratulate after the announcement (at that time she had not yet entered politics).



"As you know, I have been an ardent admirer of yours since that journey to England in 1937 (when they met on the boat), and have regarded you as the "Rathna" of India. I am happy to learn that now you are officially a Bharat Ratna. It is a title that you richly deserve."

Raman promptly responded and thanked Indira Gandhi for her message. Award was to be conferred on 26th January 1955.

On 19th January 1955, Raman received a telegram from Dr. Rajendra Prasad, The then President of India. The President wrote.....

"I shall be glad if you stay in Rashtrapati Bhavan as my guest, when you come to receive your Bharat Ratna Award. Kindly let us know your mode and date of arrival for reception arrangements."



After receiving President's telegram, Raman sent a reply to the President on 20th January 1955.

My dear Dr. Rajendra Prasad,

I was greatly touched by your very kind telegram received last night, inviting me to be your guest at 'Rashtrapati Bhavan' for the investiture Ceremony on the 27th January 1955.

Immediately on receiving the official invitation to the Investiture, I wrote to the Military Secretary and to the A. D. C. in waiting explaining that I find myself unable to come up to Delhi for the function. Even ordinarily, my work here is all engrossing and prevents me from accepting assignments which call me away from Bangalore. At the present time, I am firmly tied down here to enable one of my students to complete his Doctorate thesis which the regulations require him to submit to his university before the end of January. Thus, my duty as a teacher has to take precedence over my own personal affairs. I feel fully confident that you will appreciate the compelling nature of the circumstances which prevent me from accepting your kind and gracious invitation to come to Delhi.

Yours sincerely,
C. V. Raman

Raman stayed back in Bangalore to fulfil his obligations to his student, skipping the glamour, the glitter and the limelight of Delhi. Later, the Bharat Ratna award and the Citation were hand-delivered at his residence by an ordinary messenger of the Mysore Government. That's how Raman received the nation's highest award - no one to cheer, stand up and applaud, or even to congratulate.

The Lindau meeting* was held in 1956, where Raman lectured on "the physics of crystals in particular on the theoretical models describing the thermal vibrations of atoms in a crystal lattice". Paul Dirac, Gustav Ludwig Hertz and Werner Heisenberg were other eminent invitees in this meeting.



*The Lindau Nobel Laureate Meetings are an annual scientific conference which are held in Lindau, Germany since 1951. Their aim is to bring together Nobel Laureates and young International Scientists to foster scientific exchange between different generations and cultures.

Whom are you writing this letter to?

To our sons, Lokam. I have decided to bequeath all our assets, both, moveable and immovable. Wanted to ask them if they need anything from me. And you don't worry, even after I am gone, you will be taken care of.



Raman's elder son Chandrasekhar said he did not want anything whereas the younger son Radhakrishnan said it deemed fit if Raman dedicated all his resources to science.

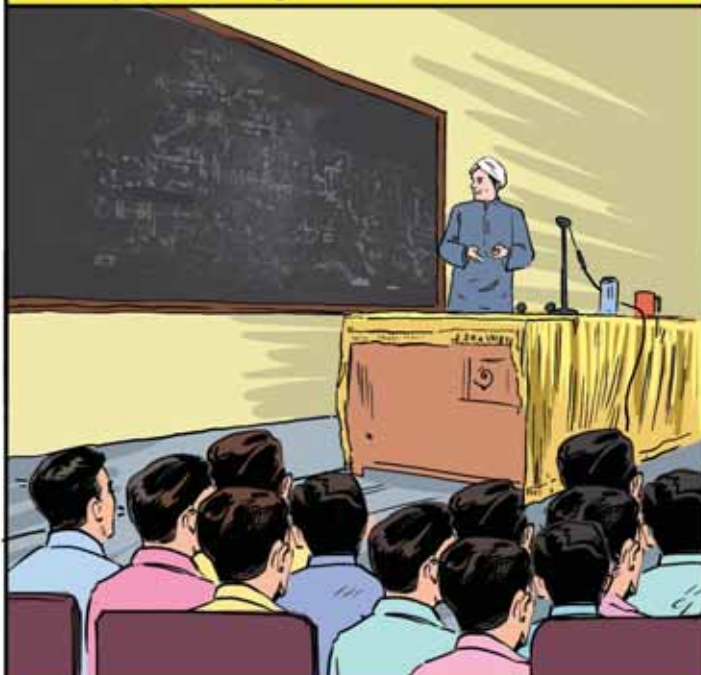
The International Lenin Peace Prize for 1956 was presented to Sir C. V. Raman at the Kremlin by academician Dmitry Skobeltsin.

I regard the award primarily as recognition of India as a sincere Champion of Peace.



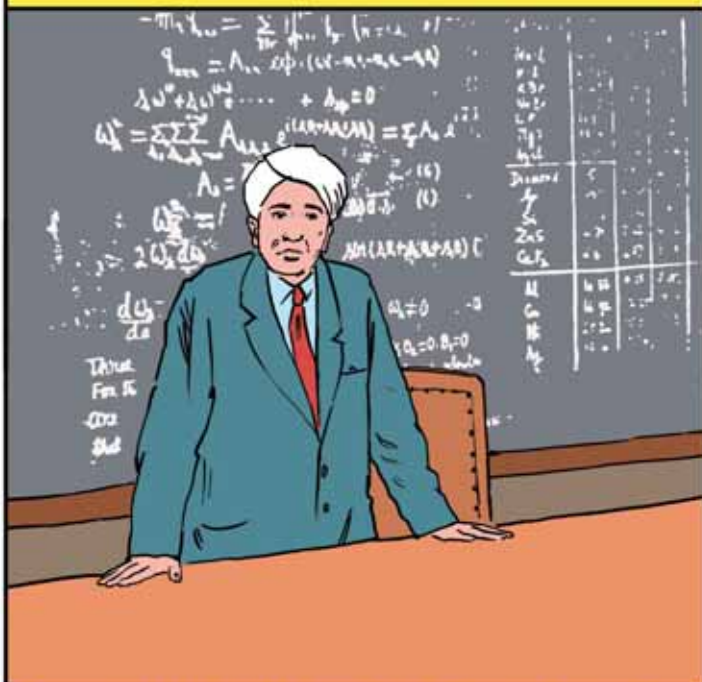
Lokam and Raman's younger son, Radhakrishnan (who became renowned radio astronomer) accompanied Raman to Russia for the Prize.

In 1958, Raman was awarded a Diploma of Honorary membership by the Hungarian Academy of Sciences in Budapest. During this visit, Raman delivered an informal talk on the 'Discovery of the Raman effect' at Budapest and Szeged Universities.



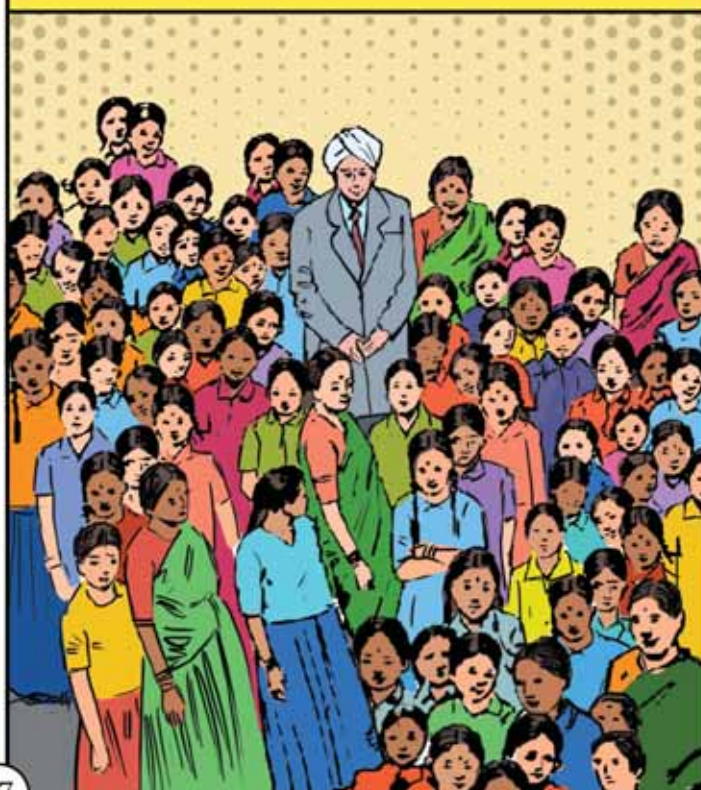
Raman's association with Hungarian scientists strengthened the relationship between Indian and Hungarian Academies of Sciences.

Raman was revered by his students as an energetic and dedicated teacher. Many of his students, including K.S. Krishnan, K.R. Ramanathan, G.N. Ramachandran and several others went on to shine in the field of science and headed science institutions of national and international repute.



Raman was thus instrumental in nurturing a generation of scientific leadership in India

Raman kept up his enthusiasm by hosting school and college students at RRI. He loved spending time with children and explaining science concepts to them. He also loved walking them through his collection of crystals and gemstones displayed in the museum.



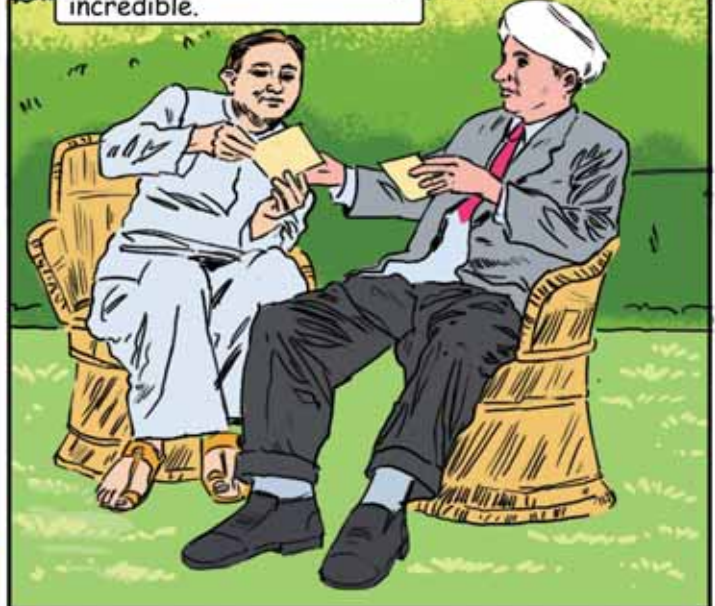
By mid-1960's, all of Raman's students had moved on to other places to further their research. Raman, now in his 70's, continued to work on his own at RRI with the same rigour and enthusiasm. He was assisted by Mohammad Kasim, the workshop incharge. K.T. Balakrishnan, who began as a glass blower and went on to become a specialist in instrument restoration, J. Padmanabhan, an expert in crystal polishing and Mohammad Khuddus, the binder.



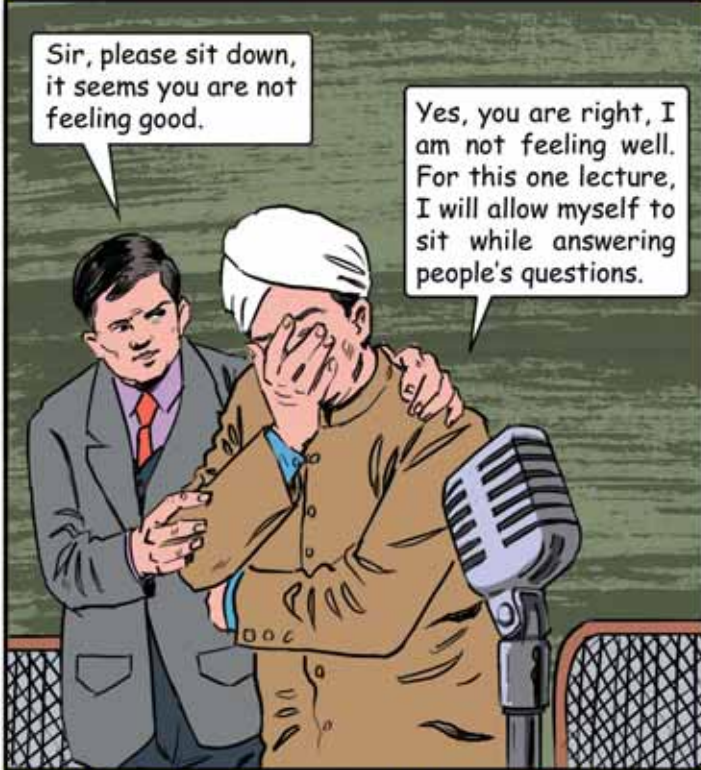
Raman personally mentored and guided them to further their career at RRI.

On the occasion of Raman's 80th birthday (in 1968), Vikram Sarabhai invited Raman to speak at the inauguration of the Community Science Centre in Ahmedabad. In his talk titled 'Why the sky is blue', Raman reiterated his love for nature.

You learn science by keeping your eyes and ears open to the world around you. To me, everything we see is incredible, absolutely incredible.



On 2nd October 1970, Raman gave his last Gandhi Memorial Lecture "On the cochlea and the perception of sound."



Sir, please sit down, it seems you are not feeling good.

Yes, you are right, I am not feeling well. For this one lecture, I will allow myself to sit while answering people's questions.

At the end of same month, he collapsed in his laboratory. He was moved to hospital.

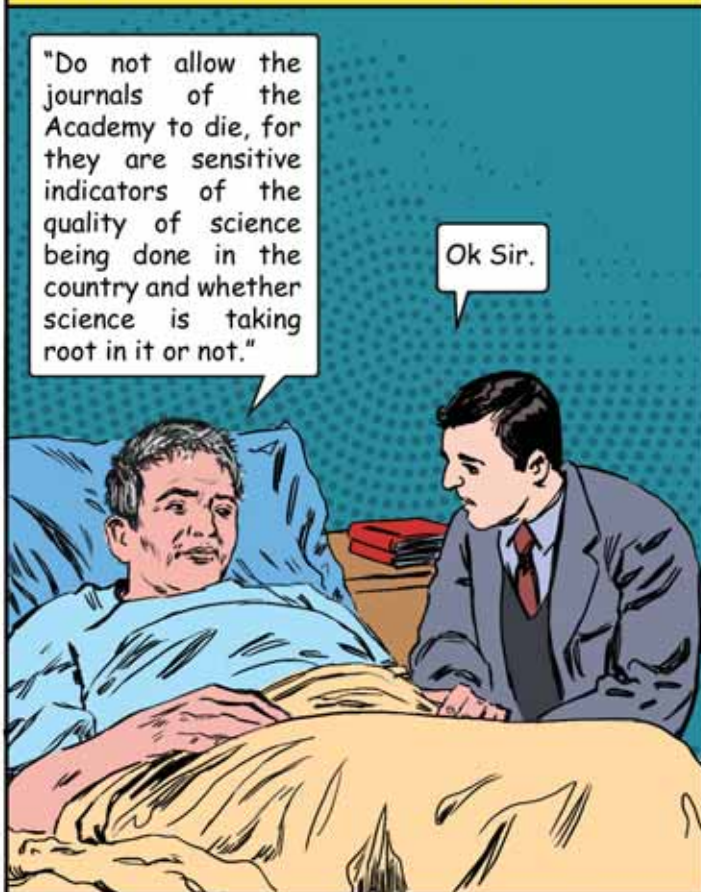
Fortunately, he survived. After few days, Raman refused to stay in the hospital as he would prefer to die in the gardens of his institute surrounded by his flowers.



I don't want to spend my last days here in the hospital. Please take me home.

Sure, we will take you home.

On the 19th November 1970, (two days before he died) he had talked to one of his former students.



"Do not allow the journals of the Academy to die, for they are sensitive indicators of the quality of science being done in the country and whether science is taking root in it or not."

Ok Sir.

The same evening he held a meeting of the Board management of the institute, conducted the proceedings from his bed, and when it concluded he dictated the minutes.

After talking to one of his former students, Raman gave his vision of the future of Raman institute.

This Institute was created by me in 1948 to provide a place in which I could continue my studies in an atmosphere more conducive to pure research than that found in most scientific institutions.

To me the pursuit of science has been an aesthetic and joyous experience. The Institute has been the heaven where I could carry on my highly personal research.

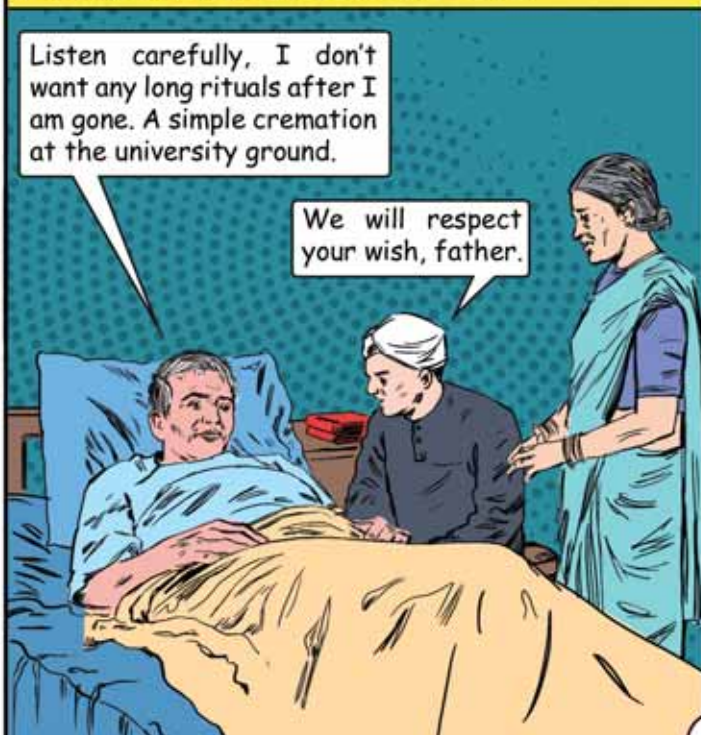
This personal character of the Institute should obviously change after me. It must blossom into a great centre of learning embracing many branches of science. Scientists from different parts of India and all over the world must be attracted to it.

With its beautiful gardens, large libraries, extensive museums, I feel that the Institute offers a perfect nucleus for the growth of a centre of higher learning.

Science can only flower when there is an internal urge. It cannot thrive under external pressures. Fundamental science cannot be driven by instructional, industrial, Governmental or military pressure. This is the reason why I decided as far as possible not to accept money from Government.

I have bequeathed all my property to the Institute. Unfortunately, this may not be sufficient for the growth of this centre of learning. I shall therefore not put it as a condition that no Governmental funds should be accepted by the Institute. I would however strongly urge taking only funds that have no strings attached.

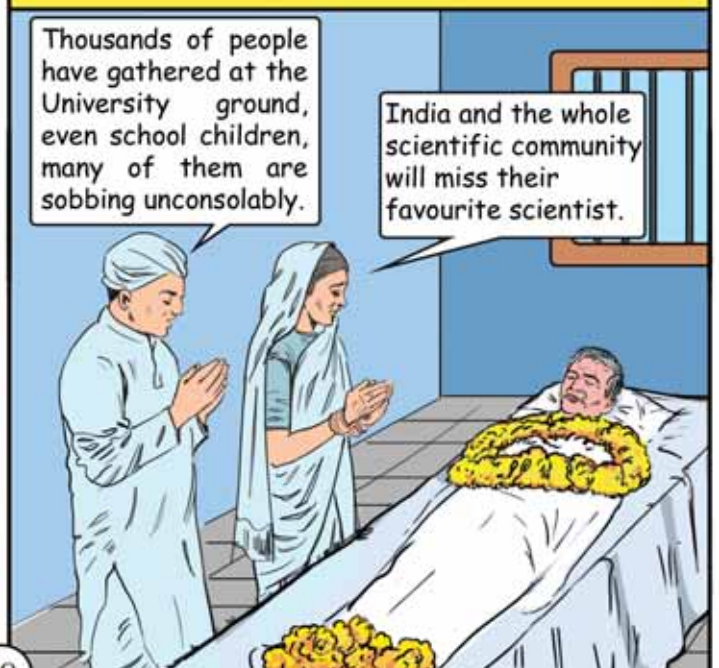
On 20th November 1970, Raman called Lokam and Radhakrishnan and expressed his desire.



Listen carefully, I don't want any long rituals after I am gone. A simple cremation at the university ground.

We will respect your wish, father.

Raman breathed his last on 21st November 1970, Saturday at 7.20 am. His death was announced on the Kannada news of All India Radio and that day was declared as a holiday in his mourning.



Thousands of people have gathered at the University ground, even school children, many of them are sobbing unconsolably.

India and the whole scientific community will miss their favourite scientist.

Raman was cremated on the same day in the afternoon at RRI. Later, the tree called the Prima Vera of Mexico was planted at the spot where Raman was cremated. It blooms once a decade. The heart-warming coincidence was that it bloomed on 28th February 1988, Raman's birth centenary year. The day is also recognised as "The National Science Day".



"C. V. Raman was the first to recognize and demonstrate that the energy of a photon can undergo partial transformation within matter. I still recall vividly the deep impression that this discovery made on all of us..."

- Albert Einstein
Nobel Prize in Physics 1921



"There is no Indian physicist of the rank of Raman. No man can compare with him in regard to vigour and intensity. This European intensity which Raman exhibited seemed to make many Indians suspicious of him."

- Max Born
Nobel Prize in Physics 1954

Publications of Sir C.V. Raman in “Nature” (world’s leading multi disciplinary science journal)

A. Vibrations and Sound

1. (1909) The small notion at the nodes of a vibrating string. *Nature*, **82**, 9.
2. (1909) The maintenance of forced oscillations of a new type. *Nature*, **82**, 156.
3. (1910) Maintenance of forced oscillations. *Nature*, **82**, 428.
4. (1921) (With G. A. Sutherland) The whispering gallery phenomenon at St Paul's Cathedral. *Nature*, **108**, 42.

B. Theory of Musical Instruments

5. (1916) On the 'Wolf note' of the violin and cello. *Nature*, **97**, 362.
6. (1917) On the alterations of tone produced by a violin mute. *Nature*, **100**, 84.
7. (1918) 'Wolf note' in pizzicato playing. *Nature*, **101**, 264.
8. (1920) (With S. Kumar.) Musical drums with harmonic overtones. *Nature*, **104**, 500.
9. (1921) Nature of vowel sounds. *Nature*, **107**, 332.
10. (1926) The subjective analysis of musical tones. *Nature*, **117**, 450.

C. Wave-optics

11. (1907) Newton's rings in polarized light. *Nature*, **76**, 636.
12. (1908) Secondary waves of light. *Nature*, **78**, 55.
13. (1909) The photometric measurement of the obliquity factor of diffraction. *Nature*, **82**, 69.
14. (1918) (With P. N. Ghosh.) The colours of the striae in mica. *Nature*, **102**, 205.
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16. (1921) A method of improving visibility of distant objects. *Nature*, **108**, 242.
17. (1922) Einstein's aberration experiment. *Nature*, **109**, 477.
18. (1922) Colours of tempered steel. *Nature*, **109**, 105.

D. Colloid studies

19. (1921) The phenomenon of the radiant spectrum observed by Sir David Brewster. *Nature*, **108**, 12.
20. (1922) The radiant spectrum. *Nature*, **109**, 175.
21. (1927) Optical behaviour of protein solutions. *Nature*, **120**, 158.

E. Molecular scattering of light

22. (1919) The Doppler effect in the molecular scattering of radiation. *Nature*, **103**, 165.
23. (1921) The colour of the sea. *Nature*, **108**, 367.
24. (1921) The molecular scattering of light in liquids and solids. *Nature*, **108**, 402.
25. (1922) Anisotropy of molecules. *Nature*, **109**, 75.

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Publications of Sir C.V. Raman in “Nature” (world’s leading multi disciplinary science journal)

26. (1922) Optical observation of the thermal agitation of the atoms in crystals. *Nature*, **109**, 42.
27. (1922) Molecular structure of amorphous solids. *Nature*, **109**, 138.
28. (1922) Diffraction by molecular clusters and the quantum structure of light. *Nature*, **109**, 444.
29. (1922) Molecular anisotropy in liquids. *Nature*, **110**, 11.
30. (1922) Molecular diffraction of light. *Nature*, **110**, 505.
31. (1922) Opalescence phenomena in liquid mixtures. *Nature*, **110**, 77.
32. (1922) Transparency of liquids and the colour of the sea. *Nature*, **110**, 280.
33. (1923) The scattering of light by anisotropic molecules. *Nature*, **112**, 165.
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35. (1923) The scattering of light by liquid and solid surfaces. *Nature*, **112**, 281.
36. (1924) The structure of molecules in relation to their optical anisotropy. *Nature*, **114**, 49.
37. (1929) Investigations of scattering of light. *Nature*, **123**, 50.
38. (1929) Colour and optical anisotropy of organic compounds. *Nature*, **123**, 494.
39. (1931) Doppler effect in light-scattering. *Nature*, **128**, 636.

F. X-rays, electron diffraction and crystal physics

40. (1923) Scattering of X-rays in liquids. *Nature*, **111**, 185.
41. (1923) Nature of liquid state. *Nature*, **111**, 428.
42. (1927) Thermal degeneration of X-ray haloes in liquids. *Nature*, **120**, 770.
43. (1927) (With C. M. Sogani.) X-ray diffraction in liquids. *Nature*, **119**, 601.
44. (1927) (With C. M. Sogani.) X-ray diffraction in liquids. *Nature*, **120**, 514.
45. (1927) Thermodynamics, wave theory and the Compton effect. *Nature*, **120**, 950.
46. (1929) (With P. Krishnamurti.) A new X-ray effect. *Nature*, **124**, 53.

G. Magnetism and magneto-optics

47. (1927) (With I. Ramakrishna Rao) Magnetic double refraction. *Nature*, **119**, 528.
48. (1929) Magnetic behaviour of organic crystals. *Nature*, **123**, 605.
49. (1929) Diamagnetism and crystal structure. *Nature*, **123**, 945.
50. (1929) Anomalous diamagnetism. *Nature*, **124**, 412.
51. (1931) India's debt to Faraday. *Nature*, **128**, 362.
52. (1931) (With S. W. Chinchalkar) A new type of magnetic birefringence. *Nature*, **128**, 758.

H. Electro-optics and dielectric behaviour

53. (1926) (With K. S. Krishnan) Electrical polarity of molecules. *Nature*, **118**, 302.
54. (1928) (With S. C. Sirkar) Disappearance and reversal of the Kerr effect. *Nature*, **121**, 794.

*Ref.:- Sr.no (Year) Title of the paper, *Journal*, **Volume**, Page

Publications of Sir C.V. Raman in “Nature” (world’s leading multi disciplinary science journal)

I. Raman Effect

55. (1928) (With K. S. Krishnan) A new type of secondary radiation. *Nature*, **121**, 501.
56. (1928) A change of wave-length in light-scattering. *Nature*, **121**, 619.
57. (1928) (With K. S. Krishnan) The optical analogue of the Compton effect. *Nature*, **121**, 711.
58. (1928) (With K. S. Krishnan) Polarization of scattered light quanta. *Nature*, **122**, 169.
59. (1928) (With K. S. Krishnan) Rotation of molecules induced by light. *Nature*, **122**, 882.
60. (1928) (With K. S. Krishnan) Molecular spectra in the extreme infra-red. *Nature*, **122**, 278.
61. (1928) (With K. S. Krishnan) The negative absorption of radiation. *Nature*, **122**, 12.
62. (1931) (With S. Bhagavantam) Evidence for the spin of the photon from light-scattering. *Nature*, **128**, 114.
63. (1931) Angular momentum of light. *Nature*, **128**, 545.
64. (1931) Atoms and molecules as Fitzgerald oscillators. *Nature*, **128**, 795.
65. (1932) (With S. Bhagavantam) Experimental proof of the spin of the photon. *Nature*, **129**, 22.

J. Viscosity of liquids and surface forces

66. (1923) The viscosity of liquids. *Nature*, **111**, 600.
67. (1923) A theory of the viscosity of liquids. *Nature*, **111**, 532.
68. (1927) (With K. S. Krishnan) The Maxwell effect in liquids. *Nature*, **120**, 726.

K. Ultrasonics and hypersonics

69. (1935) (With B. V. Raghavendra Rao) Nature of thermal agitation in liquids. *Nature*, **135**, 761.
70. (1936) (With N. S. Nagendra Nath) Diffraction of light by ultrasonic waves. *Nature*, **138**, 616.
71. (1937) (With B. V. Raghavendra Rao) Acoustic spectrum of liquids. *Nature*, **139**, 584.
72. (1938) (With B. V. Raghavendra Rao) Light-scattering and fluid viscosity. *Nature*, **141**, 242.

L. line and band spectra

73. (1922) The spectrum of neutral helium. *Nature*, **110**, 700.
74. (1925) (With S. K. Datta) Anomalous dispersion and multiplet lines in spectra. *Nature*, **115**, 946.

M. Optical and elastic properties of solids

75. (1919) Percussion figures in isotropic solids. *Nature*, **104**, 113.
76. (1921) Smoky quartz. *Nature*, **108**, 81.
77. (1921) Conical refraction in biaxial crystals. *Nature*, **107**, 747.
78. (1925) The effect of dispersion on the interference figures of crystals. *Nature*, **113**, 127.
79. (1926) The birefringence of crystalline carbonates, nitrates and sulphates. *Nature*, **118**, 264.

Pictorial Journey of Raman



The house in Tiruvanaikkaval where Raman was born



The room where Raman was born



*R Chandrasekhar Iyer
(Raman's Father)*



*Parvathi Ammal
(Raman's Mother)*



*Chandrasekhara and Parvathi with their children.
Raman is in the back row, extreme left (1899)*

SIBLINGS



*Subramanyan
(1886-1959)*



*Venkataraman
(1888-1970)*



*Mangalam
(1891-1914)*



*Skandan
(1894-1914)*



*Sundaram
(1898-1907)*



*Sitalaxmi
(1901-1971)*



*Meenakshi
(1903-1912)*



*Ramaswamy
(1907-1991)*

Pictorial Journey of Raman



Raman (standing on the right) with students of Presidency College, Madras (1906)



Married with Lokasundari (1907)



Raman's as Assistant Accountant General (1907)



Raman with Niels Bohr at the Institute of Theoretical Physics, Copenhagen (1925)



Richard Baer with Raman (1928)



Raman (front row, extreme left) at the Nobel ceremony (1930)



Raman with dignitaries at a meeting of the Indian Academy of Sciences (1934)

Pictorial Journey of Raman



Lokasundari Raman, Max Born, Raman and Hedi Born with students at the Indian Institute of Science (1937)



Raman with Birbal Sahni, the well known palaeobotanist and Sarvepalli Radhakrishnan, the second President of India



Raman with his nephew S Chandrashekar, the astrophysicist



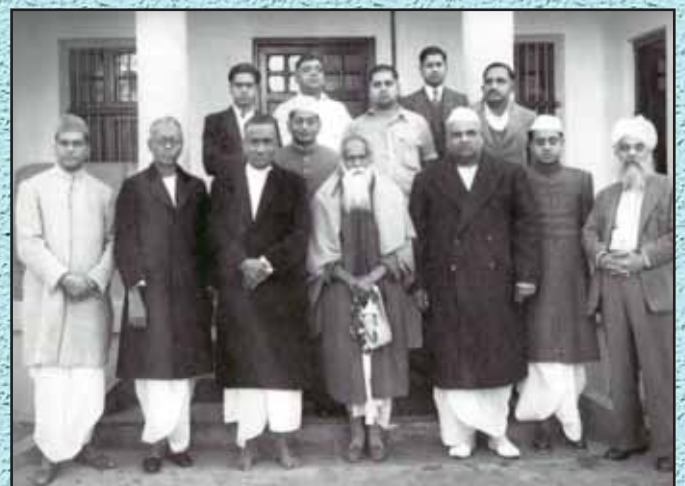
Raman with Heisenberg and Gustav Hertz



Raman with Otto Hahn



Raman at International seminars and in small-town pandals



Raman with Acharya Vinoba Bhave (centre) and others

Pictorial Journey of Raman



Raman with Sir Mirza Ismail and Max Born at the Inauguration of the Indian Academy of Sciences



John Bernal, Lrene Joliot Curie, Raman and Frederic Joliot Curie



The Raman Research Institute during its construction (1948-49)



Raman gave visitors a guided tour of the museum which contains his personal collection of minerals, crystals and other rare gems from around the world



School children & College student with Raman



The Prima Vera tree planted at the RRI lawn that marks the spot where Raman was cremated

Chronology

Years	Events / Achievements
1888	<ul style="list-style-type: none">• Birth in maternal grandparents' house in Tiruvanaikkaval near Tiruchi
1892	<ul style="list-style-type: none">• Family moves to Waltair (Vishakhapatnam)
1900	<ul style="list-style-type: none">• Matriculated with top rank from Hindu High School in Vishakhapatnam
1903	<ul style="list-style-type: none">• Joined Presidency College, Madras
1905	<ul style="list-style-type: none">• Earned B.A. degree• Received Gold Medal for Physics; Elphinstone Medal and Jagirdar Memorial Gold Medal
1906	<ul style="list-style-type: none">• Published his first paper in Philosophical Magazine
1907	<ul style="list-style-type: none">• First rank in Indian Financial Services recruitment examination• Married Lokasundari, daughter of Mr. and Mrs. Krishnaswami Iyer• Joined IFS as assistant accountant general at Calcutta• Started research at Indian Association for the Cultivation of Science (IACS), Calcutta
1909	<ul style="list-style-type: none">• Posted to Ranagoon
1910	<ul style="list-style-type: none">• Lost his Father• Posted to Nagpur
1911	<ul style="list-style-type: none">• Posted back to Calcutta
1912	<ul style="list-style-type: none">• Received Curzon Research Prize
1914	<ul style="list-style-type: none">• Sir Asutosh Mookerjee offers Palit Professorship in Physics, Calcutta University
1917	<ul style="list-style-type: none">• Resigns Government job and joins as Palit Professor
1919	<ul style="list-style-type: none">• Elected secretary of IACS after the death of Amritalal Sircar
1921	<ul style="list-style-type: none">• Awarded honorary D.Sc. Degree by Calcutta University• First trip abroad, as delegate of Calcutta University to the Congress of Universities of the British Empire, held at Oxford. Extended his trip to include research trips within England• Observes blueness of the Mediterranean Sea and speculates, it is not due to reflection of the blueness of the sky. Conducts experiments on return and published paper on the results• First son, Raja (named Chandrasekhar after his father), born in November
1924	<ul style="list-style-type: none">• Elected Fellow of the Royal Society (FRS), Second trip abroad, to Canada and the United States• Visiting Professor at California Institute of Technology on R. A. Millikan's invitation
1928	<ul style="list-style-type: none">• Discovery of Raman effect Awarded Matteucci Medal By the Italian Society of Science on August

Chronology

Years	Events / Achievements
1929	<ul style="list-style-type: none">• Knighted by King-Emperor George V of England• Invited by Faraday Society to open a discussion on Molecular Spectra and Structure at Bristol, England• Awarded Hughes Medal of the Royal Society of London• Honorary Ph.D. from Freiburg University, Honorary membership to Zurich Physical Society
1930	<ul style="list-style-type: none">• Awarded the Nobel Prize for Physics• Awarded honorary LLD from University of Glasgow
1932	<ul style="list-style-type: none">• Honorary D.Sc. of University of Paris
1933	<ul style="list-style-type: none">• Joined Indian Institute of Science (IISc), Bangalore, as first Indian Director
1934	<ul style="list-style-type: none">• Founded the Indian Academy of Sciences on 24 April
1935	<ul style="list-style-type: none">• Awarded title of Rajyasabha Bhushana By the Maharaja of Mysore• Invites Max Born to Bangalore
1937	<ul style="list-style-type: none">• Resigns from Directorship of IISc.; Continues as professor of Physics
1941	<ul style="list-style-type: none">• Awarded Franklin Medal by Franklin Institute, Philadelphia• Elected member of the Optical Society of America
1948	<ul style="list-style-type: none">• Retires from IISc.; Opens Raman Research Institute at Bangalore• Appointed National Professor, the first person to be honoured by this award• Honorary doctorate from University of Bordeaux
1954	<ul style="list-style-type: none">• Awarded Bharat Ratna - India's highest honour
1956	<ul style="list-style-type: none">• Lenin Peace Prize
1968	<ul style="list-style-type: none">• Published Physiology of Vision
1970	<ul style="list-style-type: none">• Died at his home at RRI; Cremation on RRI grounds by special permission

Bibliography

Sr. No	Books / Periodicals
01	C.V. Raman: A Biography - Uma Parameswaran, Penguin Books, 2011
02	Lady Lokasundari Raman: Reflections of Her Early Life and Times - Uma Parameswaran, Manipal University Press, 2013
03	C.V. Raman: A Memoir - A. Jayaraman, Indian Academy of Sciences, 2017
04	Raman and His Effect - G. Venkataraman, Universities Press, 1995
05	Journey into Light: Life and Science of C.V. Raman - G. Venkataraman, Penguin Books, 1994
06	C. V. Raman, A Pictorial Biography - S. Ramaseshan & C. Ramachandra Rao, Indian Academy of Sciences, 1988
07	Raman: The man, his contribution and his message - G. Venkataraman, (an address to Indian Academy of Sciences)
08	Some reflections on the life and science of Sir C. V. Raman - G. Venkataraman, J. Ind. Inst. Sci. 68 (1988) 449-460
09	C. V. Raman: The Molecular Scattering of Light - Nobel Lecture, December 11, 1930
10	C. V. Raman and The American Scientists - R. Singh, Ind. J. Hist. Sci. 38 (2003) 153-175
11	C. V. Raman - S Bhagavantam, Biographical Memoir's, Fellows of Royal Society, Page 565-592
12	C. V. Raman and the Discovery of the Raman Effect - R. Singh, Phys. Perspect. 4 (2002) 399-420
13	How costly was Raman's equipment for the discovery of Raman effect? - R. Singh, Ind. J. Hist. Sci. 53 (2018) T 68- T 73
Sr. No.	Websites Browsed
01	https://en.m.wikipedia.org/wiki/C._V._Raman
02	https://www.nobelprize.org/prizes/physics/1930/raman/biographical
03	https://royalsocietypublishing.org/doi/pdf
04	https://researchgate.net/publication

Quotes by Sir C.V. Raman

"It is not often that the idealism of student days finds an adequate opportunity for expression in the later life of manhood".

"I strongly believe that fundamental science cannot be driven by instructional, industrial and government or military pressures".

"You can't always choose who comes into your life but you can learn what lesson they teach you".

"I am the master of my failure... If I never fail how will I ever learn".

"It was poverty and the poor laboratories that gave me the determination to do the very best I could".

"The whole edifice of modern physics is built up on the fundamental hypothesis of the atomic or molecular constitution of matter".

"Success can come to you by courageous devotion to the task lying in front of you".

"Ask the right questions, and nature will open the doors to her secrets".

"The face of nature as presented to us is infinitely varied, but to those who love her it is ever beautiful and interesting".

"There is only one solution for India's economic problems and that is science and more science and still more science".



CHANDRASEKHARA VENKATA RAMAN (1888-1970)

Sir Chandrasekhara Venkata Raman was born at Thiruvanaikkaval near Thiruchirapalli, (Tamil Nadu) in South India on the 7 November 1888. He passed his B.A. in 1904 (Gold Medal) in physics and M.A. degree in 1907, with record marks. Raman felt the urge towards scientific research while he was still a student and undertook original investigations in acoustics and optics. He always found opportunities to keep up his interest in science and conduct experimental investigations, even when he was working in the Indian Finance Department as Assistant Accountant General in Calcutta.

Raman was elected as a Fellow of Royal Society (FRS) in 1924. The British Government in India conferred Knighthood on him in 1929. He received the Nobel Prize for Physics in 1930 for discovery of inelastic scattering of light by molecules (later came to be known as Raman Effect). In 1954, the Government of India awarded him 'Bharat Ratna', first scientist to have been honoured by the highest civilian award. The Soviet Union awarded him with the International Lenin Prize in 1956.

Raman became the first Indian Director of Indian Institute of Science (IISc.) in 1933 and established the Indian Academy of Sciences (IASc.) in 1934. He founded Raman Research Institute (RRI) in 1948 and was its Director till his demise in 1970. He was a self-made man and had always set an example for his associates and students, of hard work, indomitable will and total dedication to science.

This picture book is a dedication to this luminary scientist whose scientific contributions will keep inspiring every Indian scientist to achieve greater heights in science and technology.