

# Women in Physics and Mathematics

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**Women in Science**  
An Indian Academy of Sciences Initiative



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*Oct. 19, 2016,*

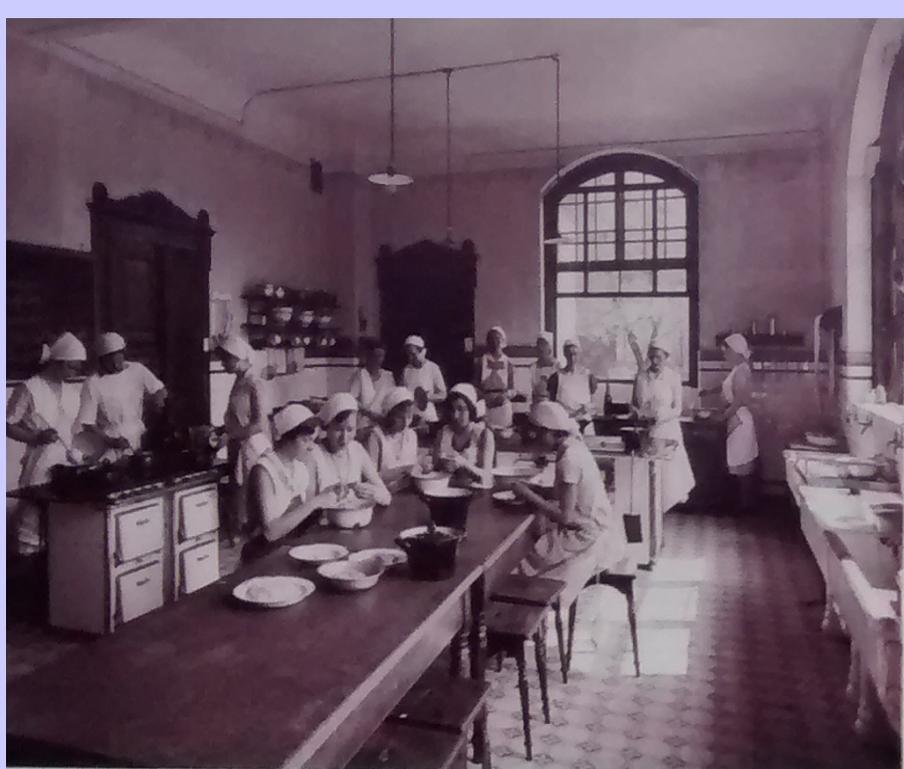
*WE Heraeus Foundation*



# Plan

- 1) Origin of the idea of this colloquium and preliminary remarks*
- 2) Inspiring stories of women of physics and mathematics from history upto middle of 20 th Century. What do we learn from the stories?*
- 3) What is the current situation?  
Have the issues changed? What needs to be done?  
What are we doing in India? Some lessons learnt*





Die  
Lehrküche  
der  
Haushaltsschule



# Origin of the colloquium



*Solvay Conference 1927*

*Only one woman*

*Mme Marie Curie*



*ICTP conference 1960*

*single woman but not  
a physicist*

## Why discuss issues of women in science?

*Number of women doing science small world over*

*Is that necessarily bad?*

*Yes..it is certainly not the optimal use of humanity's intellectual potential. Diversity can only be good for science, as for any creative activity.*

*Changing economic realities mean that the number of women participating in science is going to increase.*

*Important to discuss what efforts will make this more efficient and more effective!*

## Some myths, some biases...

***U.S. Supreme Court Chief Justice Roberts (2015)***

*“What unique perspective does a minority student bring to a physics class?”*

***Tim Hunt (Nobel Prize winner 2011: Physiology and Medicine) (Interview in 2015)***

*“Let me tell you about my trouble with girls ... three things happen when they are in the lab ... You fall in love with them, they fall in love with you and when you criticise them, they cry.”*

Why focus on physics and mathematics?

*We are a long way from gender equity in science!  
Numbers are small across all disciplines.. but some  
are more unequal than others!*

*i.e. the numbers are even smaller in physics and  
maths generally compared to other disciplines.*

*Harvard President: Larry Summers*

*“Women lack capability in Mathematical and  
Physical Sciences”*

# Women's day slogan 2016!

## *Pledge for Parity*

**There is hope to fulfil such pledges if we scientists discuss and try to look at the issue like a scientific problem.**

**Discussions therefore should not be restricted to **Women** NOR only to **Women's conferences** or to **women's day!****

# About myself: context WiS

Founder chair of the WiS panel of the Indian Academy of Sciences.

An invited speaker (among 9) at the first IUPAP International Conference on Women in Physics held in Paris in 2001 & **involved with the IUPAP group on Women in Physics since then.**

Involved in bringing out INSA report on 'Science Career for Women in India' in 2004 .

Member of the Standing Committee of the GOI for Women in Science.

About myself: context Women in Science (**WiS**)

Chair of the **WiS** panel of the Indian National Science Academy and **Member Joint Panel** of all the three academies for '**Women in Science**'. *Member also of a similar group for AASSA.*

Author of survey-report: '*Trained Scientific Woman Power: what fraction are we losing and why?*'

# About myself: context WiS

Co- Editor (with R. Ramaswamy) of two books to encourage girls to take up Science:

**1) Lilavati's Daughters : Women in Science in India  
(Publisher: Indian Academy of Science, 2008)**

**2) A Girl's Guide to Life in Science:  
(Publisher: Young Zubaan, 2010)**

Can be seen at

<http://www.ias.ac.in/womeninscience/>

**Copies in ICTP library.**

# Reference



*Association of Academies and  
Societies of Sciences in Asia:*

*AASSA report*



*India Report prepared by  
Rohini Godbole and R.*

*Ramaswamy*

# References

I have collected information over the years from various sources. But at present I will list one or two sites which have a lot of information.

## Women in mathematics:

1) [agnesscott.edu/lriddle/women/chronol.htm](http://agnesscott.edu/lriddle/women/chronol.htm)

2) [womenshistoryabout.com/od/sciencemath1/ss/Women-in-Mathematics-History.htm#step1](http://womenshistoryabout.com/od/sciencemath1/ss/Women-in-Mathematics-History.htm#step1)

# References

Women in physics:

The web site maintained by APS and links from there provide a lot of information:

- 1) <http://www.aps.org/programs/women/>
- 2) There is also a very nice set of articles by Nina Byres

# Women in Science in Greek times!

(350) 370—415 (416)?

**Hypatia: certainly one of the earliest known woman mathematician.**

*Daughter of Theon who was the last known member of the Library of Alexandria.*

**She created commentaries of classic mathematical works and lectured to students. Was also a philosopher.**



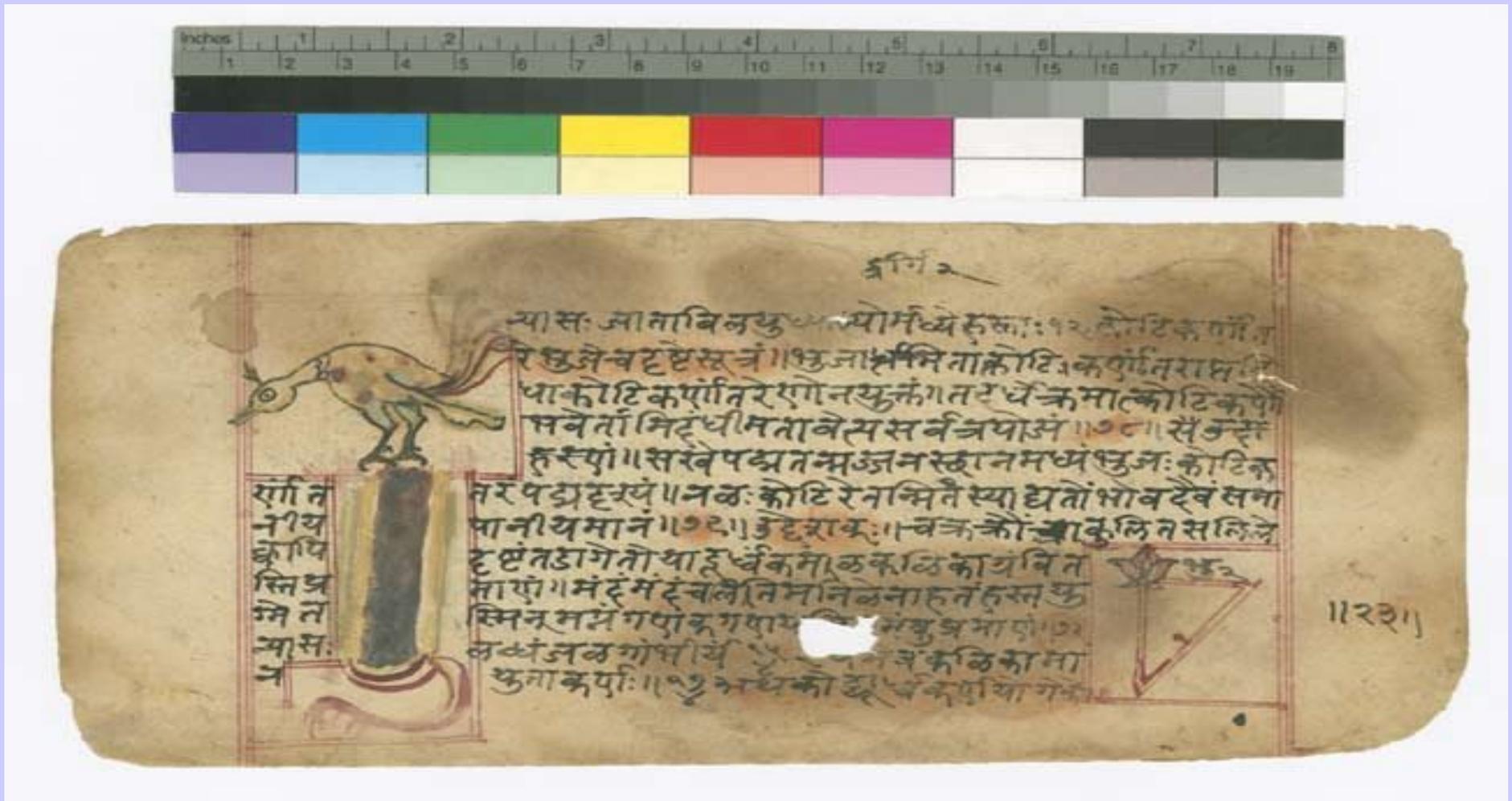
# An Indian mathematician?

In the 12<sup>th</sup> century mathematics in India was flourishing. A treatise on arithmetic written by Bhaskara-II (one copy of the manuscript in Courant Institute) is called 'Lilavati'. In this he writes most of the problems addressed to 'Lilavati' (the book is dated to be 1150):

*"Fawn-eyed child Līlāvātī, tell me, how much is the number [resulting from] 135 multiplied by 12, if you understand multiplication by separate parts and by separate digits. And tell [me], beautiful one, how much is that product divided by the same multiplier?"*

# Lilavati?

*The book contains many problems as verses and are often illustrated*



# 17<sup>th</sup> century

*Elena Lucrezia Cornaro*

*Piscopia: (1646-1684)*

*Was not allowed to study  
theology because she was a  
woman.*

*(Margarete Alic)*

*But allowed to study Philosophy*

*First woman Ph.D. in 1678*

*University of Padua*



# 18<sup>th</sup> Century

1) 1706-1749 : *Emile du Chatelet*

2) 1718-1749: *Maria Agnesi*

3) 1776-1831: *Sophie Germain*

4) 1799-1847: *Mary Anning*

5) 1780-1872: *Mary Sommerville*

6) 1750-1848: *Caroline Hershel*

# Sohie Germain (1776-1831)

Self taught. Had to fight against the family and society. **It was not proper for a**

**'middle' class girl to study mathematics and science! Lack of formal training!**

Women not allowed in Ecole Polytechnique

Used a pen name of a friend to communicate with Lagrange, Gauss.

**Important work on theory of elasticity and fermat's last theorem . First woman to win a prize from French Academy**



**The family took away her candles so that she should not study at night!**

Quote from Gauss:

“How can I describe my astonishment and admiration on seeing my esteemed correspondent M leBlanc metamorphosed into this celebrated person. . . when a woman, because of her sex, our customs and prejudices, encounters infinitely more obstacles than men in familiarising herself with [number theory's] knotty problems, ....”

“She [Germain] proved to the world that even a woman can accomplish something worthwhile in the most rigorous and abstract of the sciences and for that reason would well have deserved an honorary degree”

## *Mary Somerville (1780-1872)*

**She was drawn to Mathematics by equations**

**appearing in a fashion magazine! Father**

**opposed studying science. She was married .**

**After the death of her first husband, the second**

**husband was extremely supportive.**

**Supported by John Playfair. In contact with**

**Babbage and Herschel. Translated books by**

**Laplace and made commentary. Her work**

**inspired search for Neptune! First woman**

**(honorary) member of the Royal Astronomical**

**Society**



**Woman of Science. She wrote about the process of Science.**

# Caroline Herschel (1750-1848)

Astronomer: sister of William Herschel.

Came to England to help her brother keep house!

As Royal Astronomer William Herschel asked the king to 'pay' his assistant.

So she became the first woman who got paid for her research! Got a gold medal of Royal Astronomical Society

Contributed to searches of nebulae, clusters, comets!



Referred to herself as Cindrella of the family!

# 19<sup>th</sup> /20<sup>th</sup> Century

- 1) 1815-1852: *Ada Lovelace (Developed first algorithm)*
- 2) 1850-1891: *Sofia Kvalevskya (mathematician)*
- 3) 1818-1889: *Maria Mitchell (USA) (Astronomer)*
- 4) 1867-1934: *Marie Curie*
- 5) *Charles Angas Scott (British, worked in the USA)*
- 6) 1882-1935: *Emmy Noether (130 years of Noether's theorem)*
- 7) 1878-1968: *Lise Meitner, theoretical physicist.*
- 8) 1912-1997: *C.S. Wu, Proved parity violation experimentally*
- 9) 1906-1972: *Maria Goeppert Meyer.*

# Ada Lovelace (1815-1852)

Daughter of Lord Byron. Encouraged by mother. **Tutored by Mary Somerville.**

Interactions with Babbage and he encouraged her to write a commentary on an article by **Luigi Menabrea** from Turin on the '**Analytical Machine**' proposed by Babbage.

**This comment contained the first algorithm.**

Literature has mentioned about doubts whether she did the work! **Unfair!**



# Sofia Kovalevskya (1850-1891)

Made a marriage of convenience to get to Europe to study mathematics. Did important work on differential equations. Mentor was Weisstrass. Became the first woman professor in Mathematics in Europe at Uppsala. Winner of Prix Bordin!

Unhappy and lonely personal life:

**"I am as miserable as a dog. No I hope for their sake that dogs can not be as unhappy as human creatures, especially as women!"**



Sometimes unfair statements about the work being Weisstrass's!

# Marie Curie (1867-1934)

*Marie Curie:*

*Life is not very easy for any of us. But what of that? We must have perseverance and above all confidence in ourselves.*

*We must believe that we are gifted for something and that must be attained!*

*Got her position after accidental death of Pierre Curie who never failed to emphasize her contribution!*



Scientist par excellence:  
man or woman!

# Emmy Noether (1882-1935)

Called a creative genius by Albert Einstein.

Did enormously important work which underpins all the theoretical physics of 20 th Century and same is true for Mathematics!

Could not get a degree for a long time because women were not allowed in the University.

First woman to get a degree from Univ. of Erlangen. Did not get a 'paid' teaching positions for 7 long years after Ph.D. In this time she was working at Gottingen and teaching Hilbert's classes.

Gave a talk at the International Mathematical Congress without a permanent position.

# Emmy Noether

Charls Anges Scott : Bryn Mawr College  
created funds for her to come to USA to  
escape Nazi Germany! A woman's college!

Used to travel to Princeton Univ. To give  
lectures. She did not like Princeton  
University men professors!

Immensly successful as a researcher,  
teacher. Noether boys and Noether Girls.

Support from family in all ways.



# Lise Meitner (1878-1968)

Lise Meitner: Austrian

Could not get a degree initially as women were not allowed!

Coined the word fission and explained the physics of the process, calculating the energy release as well as distribution of daughter nuclei. (with her nephew Frisch). Suggested experiments to Hahn who was a life long collaborator.

Her Jewish religion and gender discrimination seem to have played a role in her not getting a Nobel Prize.



Even I as a student in the early days did not know about her role!

# Maria Meyer (1906-1972)

*She was a theoretical nuclear physicist.*

*Her calculations for two photon transitions in her thesis were verified recently courtesy lasers.*

**Gave the shell model for nuclei. An important step in understanding Nuclear structure.**

**Did not have a permanent job till 1960.**

**Got the Nobel prize in 1963! Only the second woman to get a Nobel!**

Whispers about idea being from Fermi!



*I dont have any data but would like to find out whether the nepotism rule was applied to brothers or fathers!*

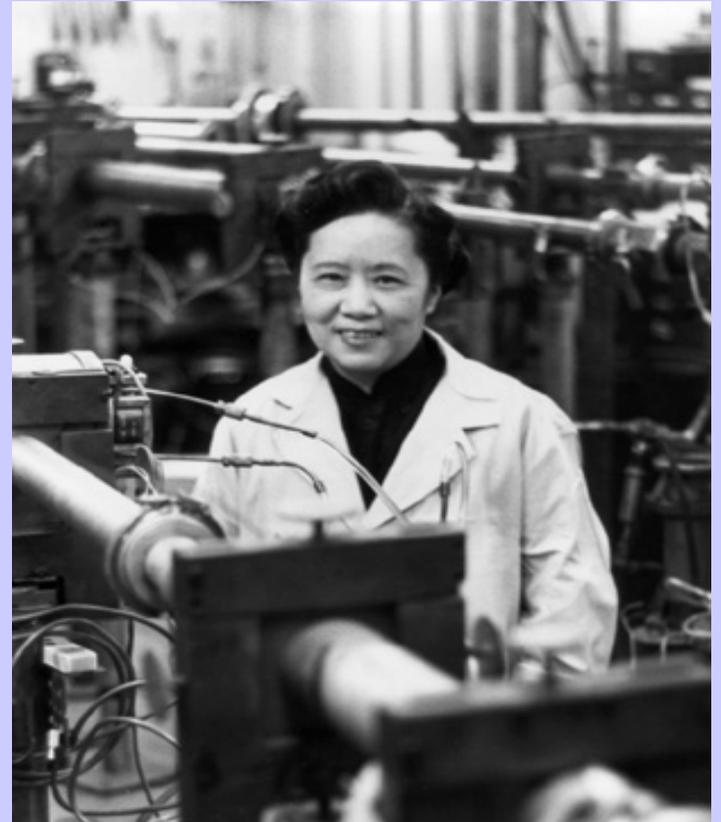
# C.S. Wu (1912-1997)

Came from China. In the US did not join Michigan because women were not allowed through front door!

Performed an experiment which proved parity violation. Much discussion and justification why she did not get the

Nobel! My take : she deserved it!

She was much feted, honoured , respected otherwise!



# Pileou

Mother of Mathematical Ecology.

Did the entire research work from home, by herself and submitted it to Univ. of London. Born 1924, got first university job 1968

Started the subject of mathematical ecology: modeling of natural systems.

Eminent Ecologist award in 1986.

Wrote a paper showing that Robert McArthur (a very eminent ecologist) was wrong. 'Correction to the McArthur formula for abundance of species'

# Pielou 1924-2016

1074

REPORTS

Ecology, Vol. 47, No. 6

## LITERATURE CITED

- Kendall, M. G. and A. Stuart.** 1958. *The Advanced Theory of Statistics*. Vol. I. Hafner Publishing Co., New York. 433 p.
- MacArthur, R. H.** 1957. On the relative abundance of bird species. *Proc. Nat. Acad. Sci. U.S.* **43**: 293-295.
- . 1960. On the relative abundance of species. *Amer. Naturalist* **94**: 25-36.
- Pielou, E. C. and A. N. Arnason.** 1966. Correction to one of MacArthur's species-abundance formulas. *Science* **151**: 592.
- Vandermeer, J. H. and R. H. MacArthur.** 1966. A reformulation of alternative (b) of the broken stick model of species abundance. *Ecology* **47**: 139-140.

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## NOTE ON MRS. PIELOU'S COMMENTS

ROBERT MACARTHUR

*Department of Biology, Princeton University*

I am happy to agree that Mrs. Pielou's formula is literally correct, and ours only an approximation. We took what amounts to an average niche subdivision and then ranked abundances; Mrs. Pielou ranked abundances and then took expectations. The distinction between these processes when applied to a single census is somewhat vague biologically and almost undetectably small numerically. Hence a graph with Mrs. Pielou's correct formula will superimpose almost perfectly on ours.

Let us hope these comments do not draw additional attention to what is now an obsolete approach to community ecology, which should be allowed to die a natural death. To forestall future waste of time, I shall add that there is also an error in my relative abundance paper (*Amer. Nat.* **94**: 25-36) in the first page of the appendix as Mr. Joel Cohen of Harvard University has kindly pointed out to me. Anyone interested may consult his paper for the correct formulation.

# So what do we learn?

All supremely confident of their science and also enjoyed their science.

Mentor support was essential.

Attitude of the community is not always helpful for women to conduct a career in science. *More sociological than academic. Academia will normally*

*bow to supreme achievements. None the less sociological biases leads to illogical obstacles. Imaginable that this can be a major cause in other cases.*

**Even if academic achievements were appreciated, here seems to be a bias in recognition and awards coming women's way!**

**Quite a few were single or married to fellow scientists!**

: Indian story today?:

**At least in academia women are not perceived as being incapable of intellectual attainment in mathematics or science (many university prize winners in science are women). We dont seem to have our Larry Summers**

***But we still dont seem to be exactly inundated with women doing science!***

# An obvious conclusion

- In India the participation of women in *studying science* or for that matter in *teaching science*, **at all levels**, is **NOT LOW AT ALL**.
- However, number of women *doing science* is certainly **NOT commensurate** with their participation in the other two aspects of scientific activity.
- Further it is even less when one considers decision making positions in this context.

# Two pronged action

There is a two pronged course of action:

**1] Societal, Mind set etc.**

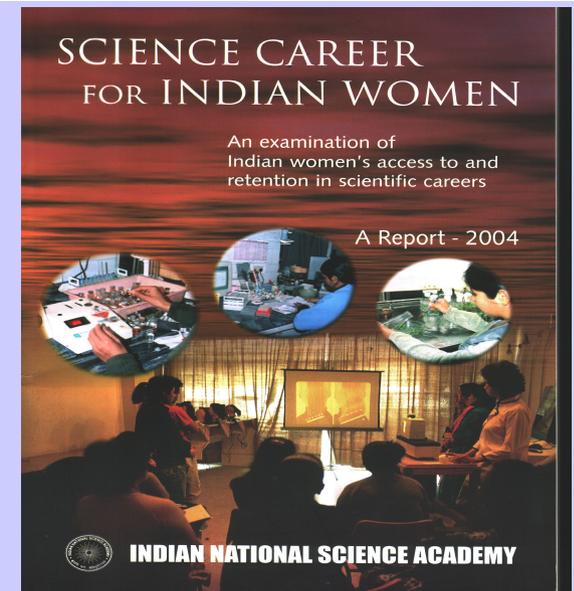
**2] Policy**

url:<http://www.ias.ac.in/womeninscience>



The Indian Academy of Sciences constituted a "Women in Science" panel to examine these questions in the Indian context.

The Indian National Science Academy had parallel effort, as did the Department of Science and Technology, with different emphases.



# Measures started before these reports

*Indian Government has been running actually a program for women to come back to science for abt 15 years. I know of few cases where these women been able to get a job in Institutions and Universties , thus getting back to a career.*

*This idea while a good measure can not be the whole story. One has to figure out measures if one can negotiate this early period without taking a break if one does not want to take a break!*

*Working on that now:-)*

# Things academicians can do

**Initiatives:**

**1) Role Model programm:**

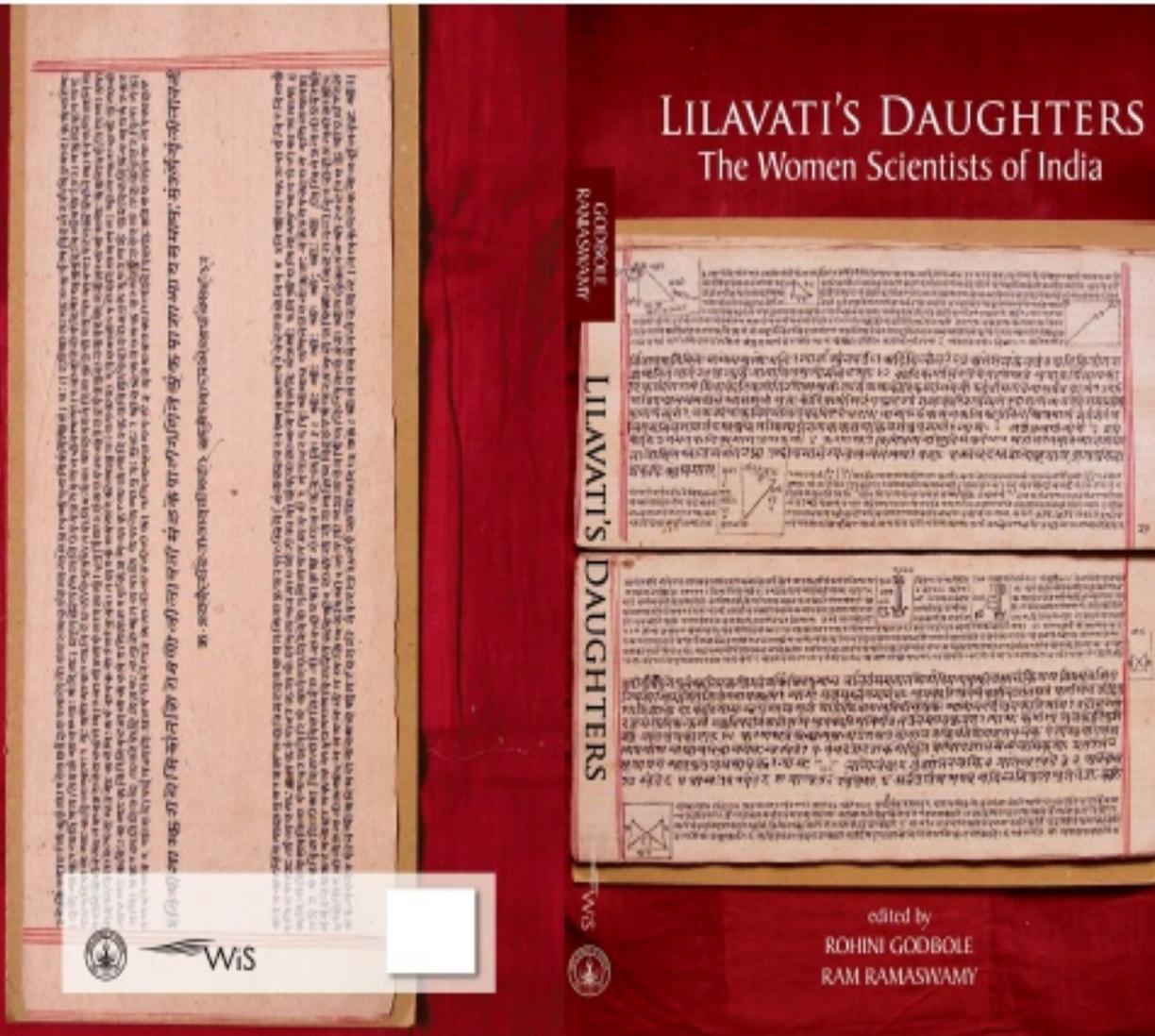
**Brought out book of (auto) biographical sketches of about 100 women Scientists:**

***a) Lilavati's Daughters: Women Scientists of India***

***b) DST brought out a book called "The Balancing Act"***

The book is available from Indian Academy. DST supported distribution of this book to schools and colleges, **Translations in some local languages.**

to science, what kept their interest alive, and what has helped them achieve some measure of distinction in their careers. The young student with research ambitions will find this an important collection where she or he can learn first-hand of women who functioned and achieved their goals in the Indian social and academic environment. We believe that others will also find the essays to be of value and interest for what they say. And also for what they do not say...



The Lilavati is a twelfth century treatise in which the mathematician Brahmagacharya addresses a number of problems to his daughter, Lilavati. Although legend has it that Lilavati never married, her intellectual legacy lives on in the form of her daughters- the women scientists of India. What makes a successful career in science possible for a woman? We believe that the many answers to this question can be found somewhere in the essays written by Lilavati's Daughters. This collection of biographical and autobiographical sketches is one of the initiatives of the Women in Science (WIS) panel of the Indian Academy of Sciences, Bangalore. Covering a range of disciplines, in these essays about one hundred Indian women scientists talk of what brought them

edited by  
ROHINI GODBOLE  
RAM RAMASWAMY

# LILAVATI'S DAUGHTERS

## The Women Scientists of India

CELEBRATING  
BIRTHDAY

LILAVATI'S

DAUGHTERS



edited by  
ROHINI GOBOLE  
RAM RAMASWAMY

We felt that rather than look either to world history or to our own history for scientific heroines, it was necessary to tell the story as it is ...

What does it take to be a woman scientist in India TODAY?

We invited about 200 women of achievement, and profiled a few women from our modern history.

Anandibai Joshee (1865-1887)

Anandibai Joshee, the first  
Hindu woman to obtain a  
medical degree in the US at the  
University of Pennsylvania.

Learnt alphabets (marathi) at the age  
of 12! went to the USA at 17/18.

She died in Poona at the age of 22.



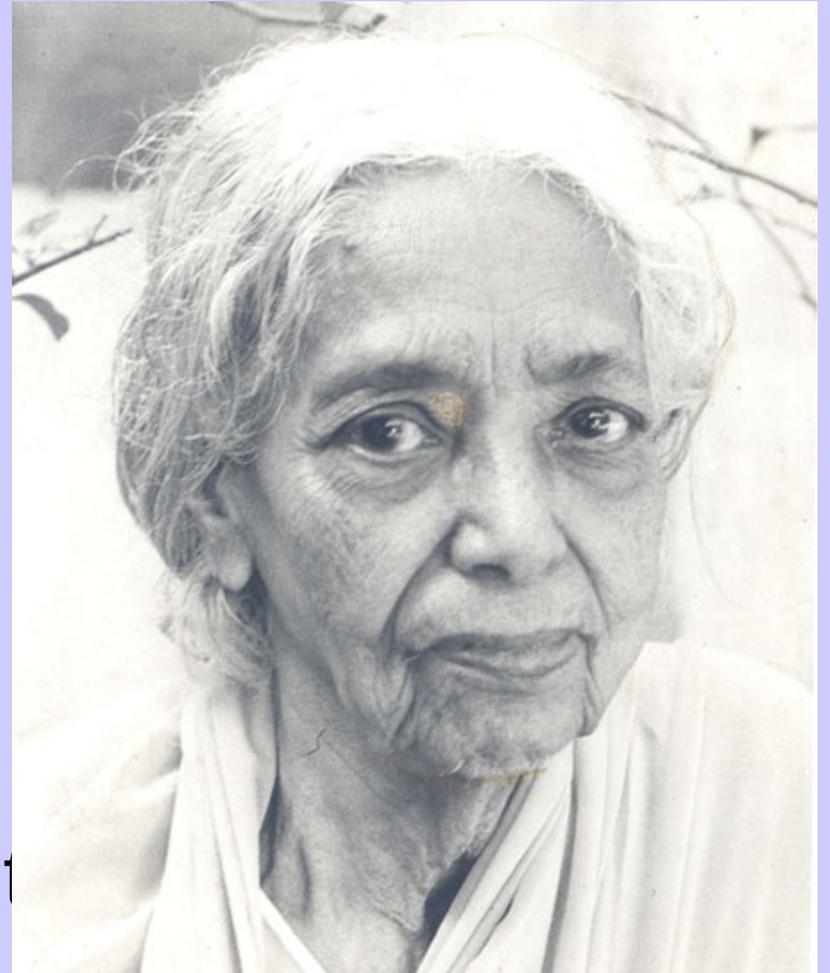
D Sc (1931, Michigan),  
Founder Fellow of the Indian  
Academy of Sciences.

The first director of the  
Zoological Survey of  
Independent India.

Received Padmashri.

Renowned botanist and plant  
cytologist who made significant  
contributions to genetics,  
evolution, phytogeography and  
ethnobotany.

Was single!





R.J. Hans Gill, Ph.D. 1965  
FTWAS, FNA, FNASc, FASc



R.J. Hans Gill in School. She  
dressed as a boy so she could  
go to a school where they  
taught mathematics!

# Common Themes

Parental (and in-law) support.

Strong role models in schools and colleges, usually female.

Help during early career, especially for raising children.

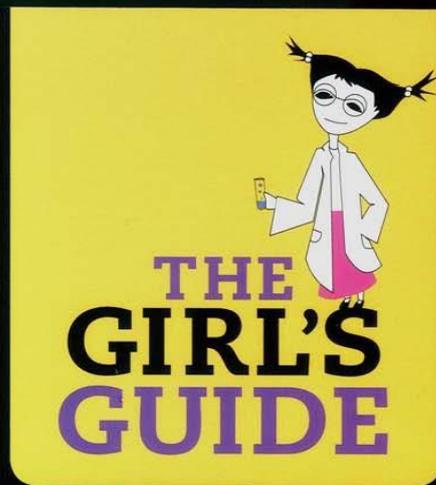
Mentors, senior colleagues.

**Chance.**

**These observations can then direct possible actions for retention and remove**

**Chance from the list!**

# Mentorship programs of the WiS



TO A LIFE IN



EDITED BY  
Ram Ramaswamy  
Rohini Godbole  
Mandakini Dubey

**A new book :  
contains a small  
description of the  
Science done by  
women whose  
stories are in the  
book .**

**They also discuss future  
challenges in their area.  
Stories of 25 women.**

# Actions

One must thus create the means to facilitate negotiation of a science career.

Awareness that it is not impossible to maintain a career/family balance needs to spread to **parents**, the **family** and **colleagues** so that this is an acceptable option. **Sensitize the parents and co students alike!**

Address gender imbalance from an early age: include young girls in programs like Science Olympiads or INSPIRE (a recent initiative of the Department of Science and Technology).

Offer financial independence through fellowships.

**Leaky pipe: find out from those who have  
left !**

**Survey: Conducted by WiS of Indian  
Academy (with NIAS)**

**Loss of trained scientific woman power :  
what fraction are we losing and why?**

**Learnt some lessons.**

**Available from:**

**[www.ias.ac.in/~womeninscience](http://www.ias.ac.in/~womeninscience)**

# Survey report is ready

Survey report ready and available at the WiS web page.

**Only 3%** of those who have dropped out, **said they dropped out due to family responsibilities.**

**66%** said they did not find jobs commensurate with their expertise!

Transparency in jobs, women friendly practices such as creche and on campus housing can go a long way

# Level playing field at all levels!

Very little of that level playing fields comes from Policy changes!

Excellence always works is a little bit of a myth!

**CNRS study: performance index for women almost 1.5 to 2 higher! There is a swedish atudy published in Nature which proves the same!**

'Epistemic Injustice' : Miranda Fricker.

An awareness of this in the community is needed!

# Summary: simple and immediate

Simple things to implement (included in our recommendation)

**1) A good creche on every campus**

**2) High priority to young couples for on campus housing**

**3) Proactive hiring policies for helping couples manage dual careers.**

**4) Encourage and reward excellence shown by women .**

**5) Improve work climate: including harassment issues.**

Serious and long term

**Gender Audit:**

**All Institutes must give on the web page information on fraction/distribution of women in faculty, students etc.**

**One needs to set up graduated goals after determining their feasibility.**

**The Goals need to be specific to sectors and Discipline**

## Two points

1)

**Lack of numerical representation is a symptom and achieving numerical targets does not mean problems are solved! Achieving the goals will be necessary but NOT sufficient.**

2)

**The Goals need to be specific to sectors and Discipline.**

# For your amusement(March 2015)



BMJ 2014;349:g7094 doi: 10.1136/bmj.g7094 (Published 11 December 2014)

Page 1 of 4

## RESEARCH

CHRISTMAS 2014: GOING TO EXTREMES

### **The Darwin Awards: sex differences in idiotic behaviour**

 OPEN ACCESS

Ben Alexander Daniel Lendrem *student*<sup>1</sup>, Dennis William Lendrem *project manager, Institute of Cellular Medicine*<sup>2</sup>, Andy Gray *consultant orthopaedic trauma surgeon*<sup>3</sup>, John Dudley Isaacs *director, Institute of Cellular Medicine*<sup>2</sup>

<sup>1</sup>The King Edward VI School, Morpeth NE61 1DN, UK; <sup>2</sup>Newcastle University, Newcastle NE2 4HH, UK; <sup>3</sup>Major Trauma Centre, Royal Victoria Infirmary, Newcastle NE1 4LP

# For your amusement(March 2015)

3/5/2015

Are men stupid? - CERN Courier

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CERN Courier

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**CERN COURIER**

Jan 27, 2015

## **Are men stupid?**

The Darwin Awards are given to people who have done idiotic things that have led to their demise and elimination from the gene pool. Now, a study of the data from 1995–2014 by Ben Lendrem, a student at the King Edward VI School in Morpeth in the UK, has revealed a disturbing trend. Of the 413 award nominations, 332 were independently verified and confirmed. Of these, 282 went to men and 36 to women. Men are, therefore, significantly more likely than women to receive the dubious award ( $P < 0.0001$ ). Any final conclusions are left to the reader.

### **About the author**

Compiled by John Swain, Northeastern University.

### **Further reading**

B A D Lendrem *et al.* 2014 *BMJ* 2014;349:g7094.

**Conclusions are left to the reader**

**Conclusions are therefore clear:**

**Measures need to be taken at all levels**

**A) Change the mind set**

**B) Change the policies**

**Gender Audit is perhaps the need of the time!**

# What is the main goal?

Major aim should be creation of support structure, societal and institutional , to help negotiate a family and career balance.

Even more important than providing ways to come back after a break is to remove the necessity for a break at all!  
Science is a way of Life ..not just a job!!

Thank you