Role of J.C. Bose Fellowship in empowering women scientists in India

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The under representation of women in Science, Technology, Engineering and Mathematics (STEM) is always a matter of concern worldwide. The sustainability of women scientists in STEM and further getting recognition, awards, rewards and leadership position has been a challenge. However, some of the women scientists have received fellowships like J.C. Bose Fellowship and secured leadership positions. This article analyses discipline-wise and institute-wise distributions of J.C. Bose women Fellows. Further, it describes notable achievements of some of the women J.C. Bose Fellows and their significant contributions in the respective research areas.

Keywords: Gender disparity, government research grants, initiatives, national fellowships, women scientists.

THE Department of Science and Technology (DST), Government of India (GoI) initiated the J.C. Bose Fellowship scheme in 2006 to recognize active, established and eminent scientists and engineers within India for their outstanding performance and contributions. The fellowship is scientist-specific and selective and covers all areas of science (in the broadest terms) and engineering. The fellowship duration is initially for five years, which may be extended for a subsequent term of five years after evaluation of the performance of the fellow during the previous fellowship tenure by a search-cum-selection committee. The fellowship can be availed by a scientist up to the age of 68 years. Under this fellowship, outstanding scientists/researchers with a proven excellent track record are provided with a personal fellowship of Rs 25,000 per month and a research grant of Rs 15 lakhs per annum to enable them to pursue research in cutting-edge areas of science and engineering. There is no fixed number of fellowships. As of now, more than 400 researchers have been awarded the J.C. Bose Fellowship since its introduction in 2006. The flexibility of this fellowship grant not only promotes research, but also enables scientists to pursue their intuitive research ideas. Even after their retirement and without any core institutional research grant, the J.C. Bose Fellowship keeps the researchers motivated with the ability to pursue their ideas. It also helps them sustain their productivity and nurture their excitement in the scientific journey.

The low representation of women in science and technology (S&T) is a universal truth and a matter of concern. It is a fact that in Science, Technology, Engineering and Mathematics, women are under represented. Only 30% of women participate in S&T and few hold senior positions. It is ironic that in spite of performing well in universities and securing top ranks, only a few women get recognition and attain leadership positions in academic and research institutions. It is challenging for women scientists to gain professional recognition while balancing on a personal front simultaneously. In addition, women scientists continue to face gender disparity and unequal access to resources and opportunities, which make their path more challenging.

Nevertheless, some women scientists manage to cross the barriers, achieve great heights in their scientific journey, and get recognition within the country and abroad. Some of them have been given many prestigious awards, including the J.C. Bose Fellowship. This does not devalue the enormous scientific contributions made by other women scientists who did not receive this fellowship; their work is equally important.

This article examines the institutional affiliation and discipline-wise distribution of women scientists, who are recipients of this prestigious fellowship. Further, we showcase the scientific contributions and notable achievements of some women J.C. Bose Fellows in different areas of science and engineering. They can be role models for younger women scientists and work as a catalyst to motivate them to pursue research with passion, sincerity and dedication to attain great heights in their careers.

Information source

Details of women J.C. Bose Fellows have been gathered from the database of Science and Engineering Research Board (SERB), GoI[1]. So far, SERB has recognized 40 outstanding women scientists for the J.C. Bose Fellowship from 2006 to February 2022. The notable achievements of women J.C. Bose Fellows have been ascertained from

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Table 1. Affiliation of universities/institutions of women J.C. Bose Fellows

Institution	No. of J.C. Bose Fellows
All India Institute of Medical Sciences, New Delhi	1
Banaras Hindu University, Varanasi	1
Bose Institute, Kolkata	1
Calcutta University, Kolkata	1
Central Drug Research Institute, Lucknow	2
Centre for Cellular and Molecular Biology, Hyderabad	1
Centre for DNA Fingerprinting and Diagnostics, Hyderabad	1
Indian Institute of Chemical Biology, Kolkata	2
Indian Institute of Geomagnetism, Mumbai	1
Indian Institute of Science Education and Research, Mohali	2
Indian Institute of Sciences, Bengaluru	7
Indian Institute of Technology, New Delhi	1
Indian Statistical Institute, Kolkata	2
Institute of Chemical Technology, Mumbai	1
Institute of Post Graduate Medical Education and Research, Kolkata	1
Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru	2
Jawaharlal Nehru University, New Delhi	2
National Centre for Biological Sciences, Bengaluru	2
National Institute of Immunology, New Delhi	1
National Institute of Pathology, New Delhi	1
National Institute of Plant Genome Research, New Delhi	2
Physical Research Laboratory, Ahmedabad	1
S.N. Bose National Centre for Basic Sciences, Kolkata	1
Tata Institute of Fundamental Research, Mumbai	1
University of Delhi, Delhi	2

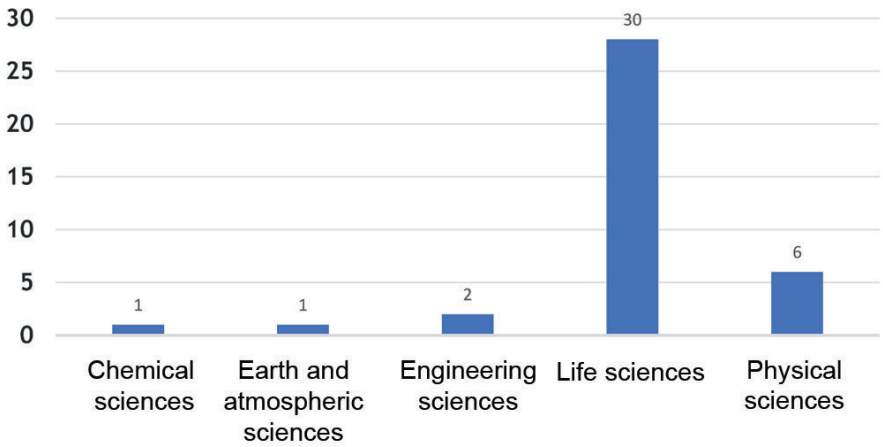

Figure 1. Discipline-wise distribution of women J.C. Bose Fellows.

their annual progress reports or directly from the women scientists.

Institutional affiliation of women J.C. Bose Fellows

Table 1 shows the institutional affiliation of women J.C. Bose Fellows (ongoing and completed). The data indicate that women scientists from the national laboratories, universities, Indian Institute of Science Education and Research (IISERs), Indian Institute of Technology (IITs), aided institutions and the Indian Institute of Science (IISc), Bengaluru have been awarded this fellowship[2,3]. The data indicate that women scientists from IISc are the forerunners in getting the J.C. Bose Fellowship (7 nos).

Discipline-wise distribution

Figure 1 indicates that women are more active in the field of life sciences (30), followed by physical sciences (6). Women have also been recognized for J.C. Bose fellowship in the field of chemical sciences (1), engineering sciences (2) and Earth and atmospheric sciences (1), but none so far in the mathematical sciences.

Women scientists who are recipients of the J.C. Bose Fellowship significantly impact science in India. Their scientific achievements and professional attainments are an inspiration to younger women who are considering a career in science and engineering. The scientific contributions of each woman J.C. Bose Fellow are enormous, which is not possible for us to showcase in one article. Here we discuss the scientific contributions and notable achievements of a few of them.

One of the women J.C. Bose Fellows has made noteworthy contributions to single-cell programmed cell death. Her studies impacted single-cell death as the report of death in the Leishmania parasite opened up a new area of single-cell death worldwide. There were significant number of citations for her first paper on unicellular apoptosis. She has made significant contributions in the field of apoptosis in general, with special reference to a model of the single cell. Although she had been doing well in research, the J.C. Bose Fellowship contributed significantly to her professional attainments. She got many prizes, awards and accolades during her fellowship tenure and published many peer-reviewed articles. She received many prestigious awards, including the Shanti Swarup Bhatnagar Medal of the Indian National Science Academy (INSA), New Delhi, in 2019. She headed the National Institute of Immunology (NII), New Delhi, during her fellowship tenure and became the first female President – Elect of INSA.

Another woman J.C. Bose Fellow is a computer scientist and her research interests include computational biology and bioinformatics, soft and evolutionary computation, artificial intelligence, machine learning and data mining. She is the first woman Director of the Indian Statistical Institute, Kolkata. She is a recipient of several awards and fellowships, including the Bhatnagar Prize, Infosys award, TWAS Prize, DBT National Women Bioscientist Award (Young), INAE Silver Jubilee Prize, Young Scientist/Engineer medals of INSA, INAE and Science Congress, J.C. Bose Fellowship, Swarnajayanti Fellowship and Humboldt Fellowship. She is a member of the Science, Technology and Innovation Advisory Council of the Prime Minister of India (PM-STIAC). In 2022, GoI awarded her the Padma Shri in the science and engineering category, which is the fourth-highest civilian award in the country. As a J.C. Bose Fellow she has primarily concentrated on developing methods in computational biology, particularly for handling single-cell RNA-seq data. In recent times, technological development has enabled the collection of gene expression data at the level of single cells. Through single cell data analysis, scientists now understand heterogeneity easily. One of her important contributions involves modelling expression-ranks as robust surrogates for transcript abundance, where the performance of the discrete generalized beta distribution on real data has been examined and a test for comparing gene expression across two phenotypically divergent groups of single cells was devised. This is particularly useful for balancing type 1 and type 2 errors and is robust to expression noise while scaling rapidly with increasing sample size. Scalable and accurate clustering algorithms have been developed to identify very small clusters while effectively handling batch effects, a major issue in biological data analysis. The impact of her work is evident from a large number of citations it has garnered over the years. According to Google Scholar, her work has been cited more than 18,000 times, and she has h-index of 57.

Another woman J.C. Bose Fellow is an outstanding Indian astrophysicist. During the tenure of the fellowship, her research has mainly focused on the origin and dynamics of various massive, non-axisymmetric planar structures such as spiral arms, lopsided structures and central bars, which are commonly observed in galaxies. These play a crucial role in galaxy evolution. Her work on multi-component gravitational instabilities showed that low dispersion, inclusion of interstellar gas, makes the disk unstable. This work is of great importance for galactic dynamics, as it showed that gas must be included for a realistic treatment of galaxies. It has also had a major impact on studies of galaxies for the past 35 years. Further, her group proposed a novel mechanism for triggering starbursts by shock compression of interstellar molecular gas clouds in interacting galaxies. The predicted results have been confirmed by subsequent observations in the literature. Even after 30 years, this model is considered a standard in the field, and has been confirmed by later high-resolution simulations by others. Her pioneering study of lopsided asymmetry in galaxies is important for galaxy evolution. Her work has established lopsidedness ($m = 1$) to be as common and important as the long-studied spiral arms ($m = 2$) in the study of galactic dynamics, and this has led to a spurt of activity in this field. She is the recipient of many awards, including the Homi J. Bhabha Medal for outstanding contributions to physics by INSA. She had been invited to join a multi-national project titled '"Stars" turbulent birth in galactic collisions' (PI Florent Renaud, UK). This was awarded 22 million core hours by PRACE (Partnership for Advanced Computing in Europe), a prestigious grant, in March 2015. She was Chair of the Indian National Committee for IAU (International Astronomical Union) during 2016–19. She was also an elected member of the IUPAP Commission on Astrophysics for two terms (2014–16 and 2017–19).

One woman J.C. Bose Fellow is a well-known biologist. She is known for her pioneering research in cardiovascular pathologies such as thrombosis. She has been working towards unravelling mechanistic insights using multipronged approaches on how reactive oxygen species and nitric oxide generation by human and rodent polymorpho nuclear leukocytes impact neutrophil functions, proliferation, differentiation and apoptosis. She is the first women director of one of the CSIR (Council of Scientific and Industrial Research) laboratories. She was awarded the National Bioscience Award for Career Development by the Department of Biotechnology, GoI, for her contributions to biosciences, which is one of the highest Indian science awards. Recently,

she was recognized with the NASI-ICMR Distinguished Professor Chair and IASTAM-Zandu International Oration Award.

Another J.C. Bose Fellow is a chemist and her main focus is on the design and development of catalytic materials for synthesizing various chemical intermediates. Her primary focus is on applying mesoporous materials, metal–organic frameworks, mixed oxides, layered double hydroxide-derived mixed-oxide catalysts, metal-ion exchanged clays for biomass conversion to chemicals and green processes for fine and bulk chemicals. She has been working on projects sponsored by industry like Vinati Organics Limited, Hikal, Godavari Biorefineries Limited, Gujarat Alkali Chemicals Limited, Indoamines, Mangalam Organics, Kesar Petro Products Ltd, Chrome Specialties, Rallis, Jubilant, Prasol Chemicals Ltd, etc. Many processes/products are either already commercialized or under discussion for commercialization. She has commercialized a process synthesizing of 3-hydoxy-2-methyl pyridine from acetylfuran, where conversion of acetyl furan is 100% with 52% selectivity of 3-hydoxy-2-methyl pyridine**.** She is the first women Director of Indian Institute of Chemical Technology across all the CSIR laboratories. She has several publications to her credit and has obtained Indian and international patents. She has been serving on many expert committees as a member or chairperson. She is the recipient of several awards, including TWAS.

Conclusion

It is evident from the data that the number of women science leaders is less and this needs to be addressed. GoI is taking various initiatives to promote women researchers and mitigate gender disparity in Indian R&D research institutions. The SERB-POWER (Promoting Opportunities for Women in Exploratory Research) programme aims to empower women researchers. It is expected that it will increase the participation of women researchers in STEM and encourage them to take up research challenges without hesitation.

1. SERB database of J.C. Bose Fellows.
2. www.serbonline.in
3. http://prism.serbonline.in

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