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HER SCIENTIFIC LEGACY: WOMEN'S IMPACT ON INDIA'S TECHNOLOGICAL RENAISSANCE

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Abstract

The previous few decades have seen tremendous advancements in science and technology. Human behaviour has altered as a result of science. Whether in the chemical, aerospace, or industrial production sectors. Agriculture, education, engineering, health, and medical advancements; infrastructure development India is gaining ground on the front-runners and becoming more visible on the international scene. In every facet of these advancements, women are essential. Once upon a time, women were expected to take care of the home while males were allowed to pursue higher education. With the passage of time and increased educational options, women now have equal opportunity in all scientific fields. This has also contributed to our country's rapid technical advancement. The article focuses on the contributions made by female scientists to the field of science and how they helped India become a model nation for the rest of the globe.

INTRODUCTION

Indian women scientists have been instrumental in shaping the scientific landscape of the nation, yet their contributions often remain obscured by prevailing gender biases and societal constraints. This abstract delves into the remarkable achievements and challenges faced by Indian women scientists across various disciplines. It highlights their significant breakthroughs in fields such as space exploration, biotechnology, medicine, and environmental science, showcasing their relentless pursuit of excellence amidst adversity. Despite facing systemic obstacles, including limited access to resources and opportunities, these women have exhibited exceptional resilience and determination, challenged stereotypes and carved a path for future generations. By examining the socio-cultural factors that influence their careers and the initiatives aimed at promoting gender equality in STEM fields, this paper enlights on the importance of recognizing and empowering Indian women scientists as catalysts for innovation and progress in the scientific community.

Historical Context:

Historically, Indian women have made notable strides in science despite societal and cultural barriers. Figures like Janaki Ammal, who pioneered research in botany, and Asima Chatterjee, renowned for her work in organic chemistry, paved the way for future generations of Indian women scientists. However, their accomplishments were often overshadowed by prevailing gender biases and limited opportunities for professional advancement. Indian women scientists have a rich historical legacy dating back to luminaries such as Rajeshwari Chatterjee, a pioneering physicist, and Anna Mani, a meteorologist known for her work in atmospheric science. Despite facing formidable societal barriers, these trailblazers made groundbreaking contributions to their respective fields, laying the foundation for future generations of Indian women scientists.

Contemporary Perspectives:

In contemporary times, Indian women scientists continue to excel across various scientific disciplines, garnering recognition on the global stage. Notable examples include Tessy Thomas, known as the "Missile Woman of India" [1], for her contributions to missile technology, and Gagandeep Kang [2], a leading virologist and vaccine researcher. Their groundbreaking work exemplifies the caliber and potential of Indian women scientists in addressing pressing global challenges. In contemporary times, Indian women scientists continue to

excel across diverse scientific domains, from aerospace engineering to biotechnology. Figures like [3], the first woman of Indian origin in space, and Rohini Godbole, a prominent theoretical physicist, exemplify the talent and resilience of Indian women scientists on the global stage. Their achievements underscore the capacity of Indian women to thrive in the face of adversity and make significant contributions to humanity's collective knowledge.

Challenges and Barriers:

Despite their achievements, Indian women scientists face multifaceted challenges in the global scientific arena. Gender bias, stereotypes, and institutional barriers persist, hindering their career progression and access to resources. Balancing professional commitments with familial responsibilities further compounds these challenges, often resulting in a leaky pipeline of women in STEM fields.

Despite their accomplishments, Indian women scientists encounter persistent challenges, including gender bias, inadequate representation in leadership roles, and work-life balance issues. These barriers not only impede their professional advancement but also perpetuate systemic inequalities within the scientific community. However, initiatives such as the Women in Science (WiS) program [4] and the establishment of gender-sensitive policies aim to address these disparities and foster a more inclusive and supportive environment for women scientists in India.

Initiatives and Interventions:

In recent years, concerted efforts have been made to address the gender gap in Indian science and provide support mechanisms for women scientists. Initiatives such as Women in Science (WiS) forums, mentorship programs, and gender-sensitive policies aim to create a more inclusive and supportive environment for women scientists. These interventions play a crucial role in empowering Indian women scientists to thrive in the global scientific arena.

Global Engagement:

Indian women scientists are increasingly engaging in collaborative research projects, international conferences, and knowledge exchange initiatives, enhancing their visibility and impact on the global stage. Partnerships with leading institutions and participation in international forums provide Indian women scientists with opportunities to showcase their expertise, build networks, and contribute to cutting-edge scientific advancements on a global scale.

This paper is organized in four chapters, Chapter I as Introduction, Chapter II provides details about women scientists and some organization for women scientists which helped women scientist to grow in their fields, Chapter III discusses the impact of work by women scientists to overall development of India and Chapter IV concludes this paper.

Literature Survey

There are many women scientists who worked in diverse areas and helped increase in technological level for India. Below are the details of some women scientists or communities and their contributions:

Dr. Tessy Thomas

Tessy Thomas, [5] born in April 1963, is a prominent Indian scientist and Director General of Aeronautical Systems, renowned for her groundbreaking work in missile technology. She made history as the first woman scientist to head a missile project in India, showcasing her natural aptitude for mathematics and physics during her education at St. Michael's Higher Secondary School and St. Joseph's Girl's Higher Secondary School in Alappuzha. Tessy holds an M.Tech in Guided Missile from the Institute of Armament Technology and pursued an MBA in Operations Management and a Ph.D. in guidance missile under the Defence Research and Development Organisation (DRDO). Joining DRDO in 1988, [6]Tessy played a pivotal role in the design and development of the Agni ballistic missile series, serving as the project director for Agni-IV and Agni-V. Her leadership and expertise in Guidance, Control, Inertial Navigation, Trajectory Simulation, and Mission Design were instrumental in the successful testing and deployment of these advanced missile systems. In 2018, she assumed the role of Director General, Aeronautical Systems of DRDO, further solidifying her position as a trailblazer in aerospace and defense technology. Tessy Thomas's outstanding contributions have garnered widespread recognition, including the Lal Bahadur Shastri National Award, the Dr. Thomas Cangan Leadership Award, and the Lokmanya Tilak National Award. She was also honored with the Woman Pioneer Award at the ETPrime Women Leadership Awards 2023, highlighting her pioneering achievements and dedication to advancing India's self-reliance in missile technology.

Rohini Shrivastava

Rohini Srivathsa [7] serves as the National Technology Officer at Microsoft India, where she spearheads initiatives to foster innovation and drive growth through 'tech-intensity' across industries and government sectors. With a background in R&D at AT&T Bell Laboratories in the USA and extensive experience in strategy

consulting with firms like the Boston Consulting Group (BCG) and IBM Global Business Services, Rohini brings a wealth of expertise in technology and business. As the former Chief Technology Officer (CTO) of Janalakshmi Financial Services (now Jana Small Finance Bank), she played a pivotal role in leveraging technology to facilitate financial inclusion among India's urban underserved population. With over 25 technical and business publications in renowned journals, Rohini Srivathsa continues to be a driving force in advancing technological innovation and digital transformation in India.

Kamal Ranadive

Born on November 8, 1917, in Pune, India, Ranadive [8] was raised in an academically inclined family, her father being a biologist at Fergusson College, Pune. Despite her father's aspirations for her to pursue medicine, she opted for Botany and Zoology at Fergusson College, where she graduated with distinction in 1934. She furthered her studies at the Agriculture College in Pune, earning her master's degree in 1943 with a focus on cytogenetics. Following her marriage to mathematician J. T. Ranadive in 1939, she relocated to Bombay. As a Senior Research Officer at ICRC, she played a pivotal role in establishing research units in Carcinogenesis, Cell biology, and Immunology. Ranadive's contributions extended to inspiring women scientists in cancer research, notably focusing on cancer among women and children. Her notable achievements include leading a study on the nutritional condition of tribal children in Maharashtra's Ahmednagar district. Recognized for her exceptional contributions, she was awarded the Padma Bhushan in 1982, along with prestigious research awards such as the Silver Jubilee Research Award from the Medical Council of India and the G. J. Watumull Foundation Prize in microbiology. Ranadive's pioneering work continues to inspire and shape the landscape of medical research in India.

Dr. Iravati Karve

Dr. Iravati Karve, [9] born on December 23, 1905, in Maharashtra, India, was a distinguished anthropologist renowned for her groundbreaking work in cultural anthropology. Educated in Pune, Maharashtra, she earned a Bachelor of Arts from the University of Bombay and later pursued a Master of Arts in Sociology. Throughout her illustrious career at Deccan College, Pune, Dr. Karve made significant contributions to the study of Indian kinship systems and cultural anthropology, notably through her seminal work "Hindu Society: An Interpretation." Her interdisciplinary approach and insightful analyses have had a profound impact on the field, enriching our understanding of Indian society and culture. Recognized nationally and internationally, she was honored with the Padma Bhushan and received prestigious fellowships for her remarkable contributions to anthropology. Dr. Iravati Karve's legacy continues to inspire generations of anthropologists and scholars worldwide.

Dr. Anna Mani

Dr. Anna Modayil Mani [10], affectionately known as "The Weather Woman of India," was born in Peermade, Travancore (now part of Kerala), in 1918. Her thirst for knowledge was evident from an early age, shaping her educational journey through esteemed institutions such as His Highness the Maharaja's School for Girls and Presidency College, Madras. Dr. Mani's illustrious career in meteorological research began after specialized studies at the Indian Institute of Science, leading to her significant contributions at the India Meteorological Department (IMD) in Pune. Rising to the position of Deputy Director General (DDG), she standardized weather instruments and established solar radiation monitoring stations nationwide, laying the foundation for India's wind energy program and advancing meteorological capabilities. Dr. Mani's research spanned atmospheric science, radiation studies, instrumentation, and tropical weather, earning her prestigious accolades including the Padma Bhushan and the Anna Mani Award. Her enduring legacy continues to inspire generations, cementing her status as a trailblazer in Indian meteorology and renewable energy research.

Darshan Ranganathan

Darshan Ranganathan [11], educated in Delhi, embarked on her scientific career with a research fellowship from the Royal Commission for the Exhibition of 1851, allowing her to pursue postdoctoral research on organic natural products at Imperial College London. Despite facing unwritten barriers to joining academia due to her husband's faculty position, she made significant contributions to research at institutions like IIT Kanpur, Regional Research Laboratory Trivandrum, and IICT Hyderabad, where she eventually became Deputy Director. Ranganathan's research focused on reproducing natural biochemical processes in the laboratory, resulting in the autonomous reproduction of imidazole, a pharmaceutical-relevant compound. She later specialized in designing proteins and nanostructures, earning recognition including Fellowships of the Indian Academy of Sciences and The Indian National Science Academy, along with awards such as the AV Rama Rao Foundation Award and the Third World Academy of Sciences award in Chemistry. Her pioneering work continues to inspire and advance the field of biochemistry and nanotechnology.

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Janaki Ammal

Janaki Ammal , [12] born on November 4th, 1897, was a pioneering Indian botanist known for her groundbreaking work in plant breeding, cytogenetics, and phytogeography. After completing her education in Madras and obtaining a master's degree in botany from the University of Michigan, she served as a Professor of Botany at Maharaja's College of Science in Trivandrum. Janaki's expertise in cytogenetics led her to the Sugarcane Breeding Station at Coimbatore, where she developed a high-yielding strain of sugarcane suited to Indian conditions and conducted seminal research on the geographical distribution of sugarcane in India. Janaki's contributions extended beyond sugarcane biology; her chromosome studies of garden plants at the Royal Horticulture Society's laboratory in England shed light on the evolution of species and varieties. Even after retirement, she continued her research, focusing on medicinal plants and ethnobotany, and established a garden of medicinal plants at the Madras University Field Laboratory. Janaki's remarkable achievements earned her several prestigious awards and honors, including the Padma Shri from the Government of India in 1977 and the institution of the National Award of Taxonomy in her name in 2000. She was elected Fellow of the Indian Academy of Sciences and the Indian National Science Academy and received an honorary LL.D. from the University of Michigan in recognition of her contributions to botany and cytogenetics. Her legacy lives on through awards instituted in her name, recognizing excellence in plant and animal taxonomy. Janaki Ammal's pioneering work continues to inspire botanists and scientists worldwide, cementing her status as one of India's most eminent botanists and a trailblazer for women in science.

Archana Sharma

Archana Sharma [13], born on February 16th, 1932, in Pune, Maharashtra, hailed from a family deeply rooted in academia. She pursued her early education in Rajasthan and later obtained her BSc and MSc degrees from the University of Calcutta, followed by a PhD and DSc under the mentorship of Professor AK Sharma. Joining the Department of Botany at Calcutta University in 1967, she rose to become a Professor of Genetics and played a pivotal role in establishing the School of Cytogenetics and the Centre for Advanced Studies in Cell and Chromosome Research. Dr. Archana Sharma's scientific contributions were prolific and diverse, with a focus on cytogenetics, genetics, and human genetics. Alongside Professor AK Sharma, she developed innovative methods for visualizing chromosome structure and made significant discoveries in the speciation of vegetatively reproducing plants. Her research extended to the induction of cell division in adult nuclei, cytotaxonomy of flowering plants, and genetic polymorphism in human populations. Throughout her illustrious career, Dr. Archana Sharma received numerous awards and honors, including the prestigious Shanti Swarup Bhatnagar Prize in 1976 for Biological Sciences. She was also recognized with awards such as the JC Bose award, FICCI award, and the Padma Bhushan, one of India's highest civilian honors, in 1984. Additionally, she held leadership positions in various scientific organizations, including the Indian Science Congress Association and the Indian Botanical Society, further cementing her legacy as a trailblazer in the field of science and education.

Kalpana Chawla

Kalpana Chawla, born in Karnal, India, was a pioneering astronaut whose remarkable journey from aeronautical engineering graduate to space explorer captivated the world. With a passion for flying and a stellar academic background, including a master's and doctorate in aerospace engineering, she joined NASA in 1988, where she made significant contributions to powered-lift computational fluid dynamics and aerodynamic optimization. Selected as an astronaut candidate in 1994, she went on to complete two space missions: STS-87 in 1997 and STS-107 in 2003. Tragically, during the latter mission, Space Shuttle Columbia and her crew were lost during re-entry into the Earth's atmosphere, leaving behind an enduring legacy of courage, dedication, and scientific pursuit. Kalpana Chawla's contributions to space exploration, along with her awards and accolades, including the Congressional Space Medal of Honor, continue to inspire future generations of scientists and astronauts worldwide.

Indian Women Scientists' Association: A Beacon of Change

In early 1970's, a few scientists got together and started thinking that it was not enough to work sincerely sitting in a laboratory, doing experiments, publishing work and living in an ivory tower. There was a major need to take Science to Society using Science and Technology for the up liftment of the "not so privileged" class of society and for women. In 1972, twelve founder members representing a wide spectrum of scientific disciplines and associated with different scientific institutions came together and registered Indian Women Scientists' Association (IWSA) on 13th June, 1973 under the Society Registration Act and the Public Trust Act on 19th July, 1973. IWSA is an All India social welfare, voluntary, non-profit, secular, non-political charitable organization. It has eleven branches namely, Roorkee (1979), Hyderabad (1979), Pune (1980), Kolhapur (1982), Nagpur (1982), Delhi (1987), Kalpakkam (1987), Vadodara (1988), Amravati (2010), Bengaluru (2018) and Nellore (2018). IWSA has about 2000 life members; its headquarters is located in Vashi, Navi Mumbai, Maharashtra.[14]

Dr. Padhye's experiences as one of the few women in classrooms and workplaces serve to underscore the systemic barriers that women in India have historically faced, particularly in the STEM fields. Rejecting the

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deeply embedded notion that women inherently lack understanding in science and technology, Dr. Padhye has consistently championed the cause of women's involvement in STEM[15] Unwilling to accept the heteropatriarchal structure of Indian society that was thwarting the progress of women in science, Dr. Padhye took a decisive step. Along with her peers, she co-founded the Indian Women Scientists' Association (IWSA). Over the past half-century, IWSA has grown exponentially, now boasting over 2,000 members and 11 branches across the nation. The association serves not just as a platform for women to engage with science, but also as a support system catering to their social and emotional needs.

More than just a professional association, IWSA serves as a second home to many of its members, providing daycare, healthcare, and a hostel for working women. The members of the association, united by their shared reverence for science, aim to empower underprivileged women who may not have any options beyond marriage and family. Dr. Padhye's unwavering commitment to mentoring and empowering future generations of women in science is reflected in every aspect of IWSA's operations. Her life's work serves as a beacon, illuminating the path for women in science in a country still grappling with gender inequity.

The mission of IWSA is clear: to bridge the gap between science and society, with a particular focus on promoting the participation and recognition of women scientists. This involves not only taking science to the masses through educational outreach and media campaigns but also fostering a scientific temper within society, emphasizing evidence-based thinking and rationality. Additionally, the initiative seeks to highlight the achievements of women scientists, serving as a beacon of inspiration for future generations. Addressing the systemic challenges faced by women in science is paramount, necessitating the implementation of policies and programs aimed at achieving gender equity and empowering women in STEM fields. Ultimately, the goal is to serve as a representative body advocating for the interests and advancement of women in science and technology, while promoting the broader objectives of scientific literacy, inclusivity, and diversity in society.

Impact on Technological Renaissance

The role of women scientists in India is multifaceted and crucial for the nation's scientific advancement and societal progress. Firstly, women scientists contribute significantly to the expansion of scientific knowledge and innovation across various disciplines, ranging from fundamental research to applied technologies. Their expertise and discoveries drive advancements in fields such as medicine, biotechnology, space exploration, renewable energy, and environmental conservation.

Moreover, women scientists play a pivotal role in inspiring future generations and breaking gender stereotypes in STEM (Science, Technology, Engineering, and Mathematics) fields. Through their achievements and visibility, they serve as role models, encouraging young girls to pursue careers in science and challenging societal norms that discourage women from entering scientific domains. Additionally, women scientists contribute to fostering a more inclusive and diverse scientific community by bringing unique perspectives and approaches to research and collaboration. Their participation enriches scientific discourse and enhances the quality and relevance of scientific outcomes.

However, it's essential to acknowledge that women scientists in India face various challenges, including gender bias, unequal access to resources and opportunities, and work-life balance issues. Efforts to address these challenges and promote gender equity in science are crucial for unleashing the full potential of women scientists and ensuring their meaningful participation in India's scientific and technological progress. Women scientists have played a transformative role in ushering in a technological renaissance across various sectors, contributing to innovation, economic growth, and societal development.

Their impact on the technological landscape can be observed in several key areas:

- Diverse Perspectives and Innovations: Women scientists bring diverse perspectives and approaches to technological innovation, leading to the development of more inclusive and user-centric solutions. Their insights contribute to the creation of products and services that address the needs of a broader spectrum of users, fostering innovation and market competitiveness.

- Breakthrough Research and Discoveries: Women scientists have been instrumental in driving breakthrough research and discoveries across a wide range of fields, including biotechnology, information technology, aerospace, and renewable energy. Their contributions have led to advancements such as new medical treatments, sustainable technologies, and cutting-edge digital solutions, shaping the course of technological progress.

- Entrepreneurship and Start-up Ecosystem: Women scientists are increasingly becoming entrepreneurs and leaders in the start-up ecosystem, founding innovative companies and driving technological entrepreneurship. Their ventures not only contribute to economic growth and job creation but also promote diversity and inclusion within the tech industry, challenging traditional norms and stereotypes.

- Role Models and Mentors: Women scientists serve as role models and mentors for future generations of technologists, inspiring young girls to pursue careers in STEM fields and providing guidance and support to

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aspiring entrepreneurs and innovators. Their visibility and leadership empower others to break barriers and pursue their passions in technology.

- Addressing Societal Challenges: Women scientists are actively engaged in addressing pressing societal challenges through technology, such as healthcare disparities, environmental sustainability, and digital inclusion. Their interdisciplinary approach and collaborative efforts contribute to the development of holistic solutions that have a positive impact on communities and societies.

Thus, Women scientists catalyze a technological renaissance through diverse perspectives, driving breakthroughs and innovation across sectors. Their entrepreneurial spirit fosters economic growth while serving as mentors and role models, inspiring future generations and addressing societal challenges through technology. Their contributions promote diversity, equity, and inclusive progress, shaping a prosperous and sustainable technological landscape.

CONCLUSION

The scientific legacy of women in India stands as a testament to their indispensable role in shaping the nation's technological renaissance. Through their pioneering research, innovative contributions, and leadership in various scientific domains, women scientists have propelled India towards the forefront of global technological advancement. Their entrepreneurial spirit, mentorship, and unwavering commitment to addressing societal challenges through technology have not only enriched the scientific landscape but also inspired future generations of scientists and entrepreneurs. As India continues its journey towards inclusive and sustainable development, harnessing the full potential of women in science will be essential for driving innovation, fostering economic growth, and building a brighter, more equitable future for all

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