



BOOKS *et al.*

HISTORY OF SCIENCE

# The calculators

Two tomes uncover how women broke down barriers to explore the universe

By Carol Christian

**A**s testimony to the tenacity and bravery of clever women, and the courage of some laboratory managers and directors, the 20th century saw the emergence of women as significant participants in astronomy and space engineering.

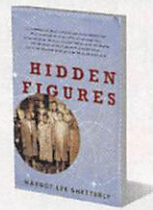
In the opening pages of *The Glass Universe*, Dava Sobel recounts how, in the wake of her husband's death in 1882, Mary Anna Palmer Draper was determined to ensure that his legacy as a trailblazer in the field of astrophotography was not forgotten. With the encouragement of Edward Charles Pickering, director of the Harvard College Observatory, she established the Henry Draper Memorial, which would support an ambitious new program that sought to classify several thousand stars from a catalog of photographs captured on glass plates. She thus became a benefactor of the observatory, providing funds and eventually a telescope, to ensure that her husband's spectroscopic work was continued. In doing so, Draper—herself an active participant in her husband's research—set in motion events that would firmly establish a role for women in modern astrophysics.

In the year of Henry Draper's untimely passing, Pickering had issued a plea requesting the help of amateur astronomical observ-

**The Glass Universe**  
How the Ladies of the  
Harvard Observatory Took  
the Measure of the Stars  
Dava Sobel  
Viking, 2016. 352 pp.



**Hidden Figures**  
The American Dream and  
the Untold Story of the Black  
Women Mathematicians Who  
Helped Win the Space Race  
Margot Lee Shetterly  
Morrow, 2016. 367 pp.



ers, who would be responsible for performing calculations on the observatory's nighttime observations. Noting the aptitude and untapped potential of the gentler sex, he had enlisted the assistance of six women “computers” by February 1883.

Sobel capably demonstrates how Pickering's cadre of women computers not only standardized the stellar brightness scale to levels fainter than the unaided eye could see but also characterized the detailed appearance of stellar spectra on plates that recorded hundreds of observations at a time. Williamina Fleming, for example, originally employed as Pickering's maid, created an extensive empirical classification scheme based on the visual appearance of the spectra. The scheme was later augmented by Antonia Maury, none other than Henry Draper's niece. Astronomers at the time were skeptical of the use of photography as a robust astronomical medium, but the women's careful analysis helped the field of astrophotography become a cornerstone of stellar astronomy.

Later, we meet Cecilia Payne, an English woman who read chemistry and physics at Cambridge University. Payne arrived at the observatory in 1923, where she would eventually determine that stars are 99% hydrogen,

Aerospace engineer Mary Jackson (played by Janelle Monáe) consults a colleague in *Hidden Figures*, in theaters 25 December 2016.

an important breakthrough counter to conventional wisdom at the time. Payne would go on to become the first woman to obtain a Ph.D. in astronomy from Radcliffe College (now part of Harvard) in 1925.

Sobel interweaves the diverse personalities and backgrounds of these and other women with stories about the evolution of the field of astronomy as a whole, including the establishment of the American Astronomical Society, and the International Astronomical Union's struggle to maintain and then reestablish international research collaborations across national boundaries during World War II (an effort in which the Harvard Observatory was a major player, according to Sobel).

*Hidden Figures*, by Margot Lee Shetterly, picks up where *The Glass Universe* leaves off, highlighting a group of African American women who made important early contributions to the space race during and after World War II. The book follows the career of Dorothy Vaughan, a former high school mathematics teacher, and her fellow female computers in the all-black West Area Computing Unit of Langley Memorial Aeronautical Laboratory, who were recruited from around the country to provide computation support for the war effort in the early 1940s.

Contrasting the headline-grabbing exploits of Tuskegee airmen with the understated but no less impressive contributions of the “colored computers,” Shetterly reveals how the women earned the respect and admiration of their colleagues. “They wore their professional clothes like armor,” she writes. “They wielded their work like weapons, warding off the presumption of inferiority because they were Negro or female.”

The women continued their work after the war, during the period when rocketry was born and competition with the Soviet Union was fierce. A film about their contributions to NASA's Project Mercury and the Apollo 11 mission based on Shetterly's book is set to be released on 25 December (*I*).

Besides being captivating reads, these two books chronicle stories of overlooked contributions of women in space science, astrophysics, and engineering in the 20th century. Both are a testimony to personal perseverance and ingenuity. Such histories enrich our understanding of the value of tapping diverse individuals to advance knowledge in any field. ■

REFERENCES

1. *Hidden Figures*, Theodore Melfi, director, Fox 2000 Pictures, 2016.

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## PUBLIC HEALTH

# The aftermath of AIDS in China

A candid history uncovers the country's stumbles and successes in the fight against the devastating virus

By Kristin Harper

**B**y the mid-1990s, the terror of the early AIDS epidemic had subsided in many western countries, as antiretroviral therapy transformed the once-deadly disease into a chronic condition. In China, however, the AIDS epidemic was just getting started. Slipping across the nation's southern borders via injection drug use, the virus went largely undetected until it exploded among tens of thousands of plasma sellers in rural China. Up to that point, many Chinese leaders had naively hoped that the absence of "social evils," such as prostitution and illegal drugs, would prevent the infection from taking root in the country. *HIV/AIDS in China: Beyond the Numbers* is a fascinating account of how the AIDS epidemic forced these leaders into action.

This slim volume is full of quotes from researchers, policy-makers, and clinicians who were on the front lines of the epidemic. On the first page, Zunyou Wu (director of the National Centre for AIDS/STD Control and Prevention at China's CDC) and Elizabeth Pisani (King's College London) state, "[E]veryone involved felt that it was important to give an honest account of these events; they all recognise that the lessons of the past have contributed in important ways to the strength and success of China's response at present."

As promised, the pages that follow are remarkable for their candor, detailing many shortfalls on the part of the Chinese government. A slow response to the plasma seller outbreak, for example, meant that even though the first HIV cases were detected in this group in the mid-1990s, many of the infected were still undiagnosed and untreated when the story broke in the national and international news around the year 2000.

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The book also details how rank-and-file researchers and patient advocates went to heroic lengths to prevent new infections. We learn, for example, how the organizers of a national training workshop that took place early in the epidemic instructed shocked participants to head outside to practice talking to sex workers; how one deputy director at the All-China Women's Federation took advantage of her boss's absence to apply for HIV prevention funds



Chinese nursing students hold ribbons in honor of World AIDS Day in 2011.

from the World Bank; and how virologist Laiyi Kang narrowly escaped arrest for instituting an experiment that provided free condoms in the bathrooms of a high-end hotel in Shanghai.

The book describes how, eventually, senior leaders took notice of the successes that these AIDS pioneers had carefully documented. When the Chinese government did decide to support prevention and treatment efforts in earnest, it did so with all of its weight. The government's spending on AIDS skyrocketed from a mere US\$2 million in 2000 to \$600 million in 2015. And between 2010 and 2014, health officials reduced the number of steps between HIV screening and treatment from 4 to 1, thus increasing the percentage of individuals with a confirmed HIV infection who had initiated antiretrovirals from 40% to 90%. Most recently, in February of this year, the

## HIV/AIDS in China Beyond the Numbers

Zunyou Wu, Ed.  
People's Medical  
Publishing House, 2016. 191 pp.



government announced that anyone with a confirmed HIV diagnosis can seek free treatment immediately, regardless of CD4 cell count.

This account of China's transformation from HIV laggard to leader will be valuable to other countries seeking to meet the Joint United Nations Programme on HIV/AIDS 90-90-90 target (i.e., by the year 2020, 90% of people living with HIV will know their status, 90% of people with HIV will receive sustained antiretroviral therapy, and 90%

of people receiving antiretroviral therapy will achieve viral suppression). In particular, countries dependent on donor funds may want to take note of the Chinese government's insistence on using international assistance to meet national objectives rather than donors' objectives and on satisfying grantors' reporting requirements with a single, centralized data platform built to meet national needs and reduce paperwork.

As the authors acknowledge, though, many features of China's system may be difficult for other nations to replicate. Few countries have such a strong central government, and whereas today over 99% of funds for HIV programs in China come from domestic sources, many AIDS-stricken countries do not have the resources to ramp up funding in this way.

As the authors point out, it remains to be seen how China will adapt to the changing HIV landscape; to what extent its top-down government will be able to partner with grass-roots community groups to reach at-risk populations; and whether the stigma that impedes prevention and treatment efforts can be reduced. However, this book offers a vivid history of China's response to HIV from the pathogen's emergence until the present, and it joins the relatively thin ranks of books that offer first-person accounts of important eras in public health. This is a must-read book for anyone interested in HIV, infectious diseases more generally, or global health. ■

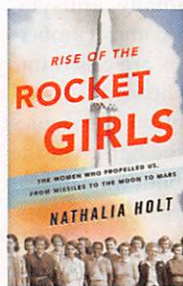
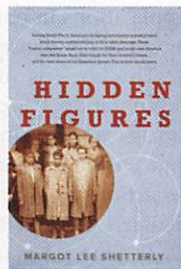
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## Hidden Figures

The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race

Margot Lee Shetterly

William Morrow, 2016, \$27.99 (368 pp.). ISBN 978-0-06-236359-6



## Rise of the Rocket Girls

The Women Who Propelled Us, from Missiles to the Moon to Mars

Nathalia Holt

Little, Brown and Co, 2016, \$27.00 (352 pp.). ISBN 978-0-316-33892-9

At perhaps no other moment in US history would stories of the first female mathematicians and engineers at NASA resonate as they do following the 2016 presidential election. Both Nathalia Holt and Margot Lee Shetterly describe the lives of previously obscure women “computers” who worked for NASA during the earliest phases of America’s space program. Shetterly’s *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race* tells the story of African American computers at the Langley Memorial Aeronautical Laboratory in Hampton, Virginia. Holt’s book, *Rise of the Rocket Girls: The Women Who Propelled Us, from Missiles to the Moon to Mars*, focuses on women at the Jet Propulsion Laboratory (JPL) in southern California. Both books slant toward popular, nonacademic audiences; a film adaptation of Shetterly’s book receives nationwide release this month (*Hidden Figures*, 20th Century Fox, 2016).

Shetterly and Holt are part of a growing contingent of journalists and historians seeking to peel back the veneer of existing institutional histories of NASA facilities and give insight into the lives of the hundreds of thousands of workers who propelled the space program from floundering rocket development to the Sea of Tranquility and beyond. Each author found inspiration for her work in personal experiences. Shetterly was inspired by her own life in the African American community around Hampton.

Holt found her subject by a more unusual path; she learned about one of the JPL engineers while searching online for name ideas for her first child.

*Rise of the Rocket Girls* and *Hidden Figures* offer moving glimpses into the growing pains of professional development for women in the post-World War II and Cold War technical workplace. Women computers at Langley and JPL forged their own career paths, frequently walking fine lines between their expected roles as wives and mothers and their desire to gain personal fulfillment through their careers.

The computers’ experiences, however, were markedly different on the two sides of the country, particularly in terms of the racial and gender barriers they faced. Racial barriers were less overt at JPL, where women of multiple races and ethnicities worked in the same offices. In contrast, Langley was not integrated until the creation of NASA in 1958. Furthermore, at JPL, computer positions were not necessarily limited to women, whereas at Langley, computer positions were gender specific. But whether internally or externally enforced, at both locations women were pigeonholed into the role of computers, and they lacked advocates at management levels who might have made career advancement possible.

Both authors make excellent use of primary sources, including oral histories, NASA documents, and newspaper articles. When scholarly works are cited, however, it appears they are only used for technical information. In drawing

back the curtain on their stories, neither Shetterly nor Holt takes advantage of the significant work by scholars of race and gender studies; doing so would have bolstered their narratives.

Shetterly and Holt also do not dig to the level of internal NASA policy, as Margaret Weitekamp did with her research on female pilots tested for astronaut training in *Right Stuff, Wrong Sex: America’s First Women in Space Program* (Johns Hopkins University Press, 2004), or relate the experiences of the female computers to the challenges faced by nonwhite males working at NASA’s Marshall Space Flight Center, as Richard Paul and Steven Moss do in their book *We Could Not Fail: The First African Americans in the Space Program* (University of Texas Press, 2015). Shetterly and Holt, unfortunately, miss the opportunity to use their stories to investigate bigger questions about the perception of and reaction to race and gender at NASA or movements for racial and gender equality.

As a woman historian, it was impossible not to feel thrilled and enlightened by the women in *Hidden Figures* and *Rise of the Rocket Girls*. Katherine Johnson, a passionate and talented mathematician whom Shetterly profiles, persisted in overcoming preconceptions of what women could contribute to human spaceflight. Susan Finley, a major figure in Holt’s book, continues to shape planetary exploration projects at JPL and inspires women professionals at the lab despite her lack of formal education.

Unfortunately, both authors tend to jump from personal to professional stories, and the sudden topic changes can be confusing and difficult to follow. Shetterly also does not distinguish clearly between the experiences of the characters she profiles and those of other women at Langley. Admittedly, telling the story of all women at Langley was not one of Shetterly’s goals, but the reader might wonder how common or uncommon the experiences of Johnson and the others were.

For narratives built on such a large number of oral histories, it was surprising not to hear more from other employees at NASA, particularly the engineers who supervised the women. The voices of those who benefited from their work would have added depth to the authors’ descriptions of the NASA work environments. Women mathematicians and

engineers at Langley and JPL faced incredible odds in pursuing personal and professional goals simultaneously, but I never got a sense of what either set of women meant to the programs for which they worked. What is quite apparent is the remarkable strength of the communities the women built to support each other inside and outside the workplace.

Although neither Holt nor Shetterly engages with the breadth of existing scholarship on race and gender issues at NASA or its predecessors, they forge new pathways for additional investigations. Taking a multibiographical approach does complicate their narratives, but those complications are necessary to relate the stories. The female technical experts, well aware of their uniqueness in their fields and in their places of employment, played important roles in human and robotic spaceflight, despite decades of being hidden from public view. Uncovering and telling such stories will hopefully lead to deeper scholarly examinations that will enrich our understanding of what women of all backgrounds meant to NASA and what NASA continues to mean to young women interested in careers in science, technology, engineering, and mathematics.

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## Group Theory in a Nutshell for Physicists

**A. Zee**

Princeton U. Press, 2016. \$90.00 (632 pp.).  
ISBN 978-0-691-16269-0

Many books have been written about group theory's applications to physics. Some have an arid, mathematically rigorous style that often obscures physical insight. Other, less formal presentations usually cannot deliver the necessary know-how for practical applications. In *Group Theory in a Nutshell for Physicists*, Anthony Zee, a physicist at the University of California, Santa Barbara, combines clarity of presentation with mathematical detail at a level of rigor acceptable to physicists. The result is a tour de force that guides readers through the universe of group theory and leads them to recent



applications in particle physics, cosmology, and condensed matter.

The book is unique in its laid-back presentation. It is peppered with colorful stories about famous mathematicians and physicists and includes frequent interjections from fictitious characters. Particularly helpful are the mutterings of Dr. Feeling, who supplies intuitive understandings of formal definitions or theorems, and the observations by Confusio, who (not surprisingly) points out issues of possible confusion. The book is ideally suited to accompany a graduate course on symmetries in physics because of its pedagogical approach, the detail of its illustrative examples, and its many exercises. Readers need to be familiar with the basics of quantum mechanics, but little other advance knowledge is required since the book starts with a brief review of linear algebra and a reminder of the properties of matrices.

After its mathematical refresher, the book turns to a detailed presentation of the representation theory of finite groups and the introduction of Lie groups. Early on, Zee introduces Lie algebras by way of three-dimensional rotations; the classification of those algebras by roots, weights, and Dynkin diagrams comes later. The book's mathematically detailed material is interspersed with group theoretical applications to physical systems. Given the author's distinguished career in particle physics, it is not surprising that most of the examples come from that field, but Zee occasionally ventures out to other areas with examples relevant to condensed-matter and atomic physics.

The book makes only a single mention of group theory applied to atomic nuclei (my field of expertise), and that appears as a footnote when Zee discusses the Elliott model. James Philip Elliott's application of  $SU(3)$  is admittedly of less fundamental importance than the application of that group to particle physics, but the mathematics behind Elliott's application is more sophisticated. After reading about how the finest minds in the particle-physics community struggled to get the eightfold way right, I can only admire Elliott's achievement even more, as he developed the  $SU(3)$  model of nuclei essentially by himself.

The book does not comprehensively discuss the represen-

tation theory of the symmetric group of permutations, and the author even advises readers to stay clear of the diagrammatic machinery of Young tableaux. That may be sensible advice when one is dealing with low-dimensional representations. However, as the dimension of the representation increases, as is the case, for example, in quantum many-body physics, Zee's treatment in terms of either totally symmetric or totally antisymmetric tensors rapidly becomes cumbersome, and Young tableaux are called for.

Eugene Wigner, who introduced group theory into quantum mechanics and is therefore one of the heroes of the book, famously wrote about the "unreasonable effectiveness" of mathematics. In the final chapters of his text, Zee forcefully makes the case for the unreasonable effectiveness of group theory and buttresses his case with many compelling examples. Group theory can generate everything from the Dirac equation for the electron to the equations that describe the expanding universe. Indeed, all known particles can be unified within the framework of the Lie group  $SU(5)$ .

With *Group Theory in a Nutshell for Physicists*, Zee convincingly demonstrates that group theory governs the physical universe, and he gives aspiring physicists the tools to understand its applications to their work.

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## Strange Glow The Story of Radiation

**Timothy J. Jorgensen**

Princeton U. Press, 2016. \$35.00 (512 pp.).  
ISBN 978-0-691-16503-5

Timothy Jorgensen's *Strange Glow: The Story of Radiation* has two purposes: to educate the lay public about the various real and imagined health risks radiation poses to humans and to tell "the story of radiation," as his subtitle has it, from x rays to mobile phones. An accomplished radiation biologist, Jorgensen succeeds as a communicator of the current state of the fraught and fluid field in which he works. *Strange Glow's* historical account is less adept, however. General audiences will likely struggle with an overabundance of detail, while histori-