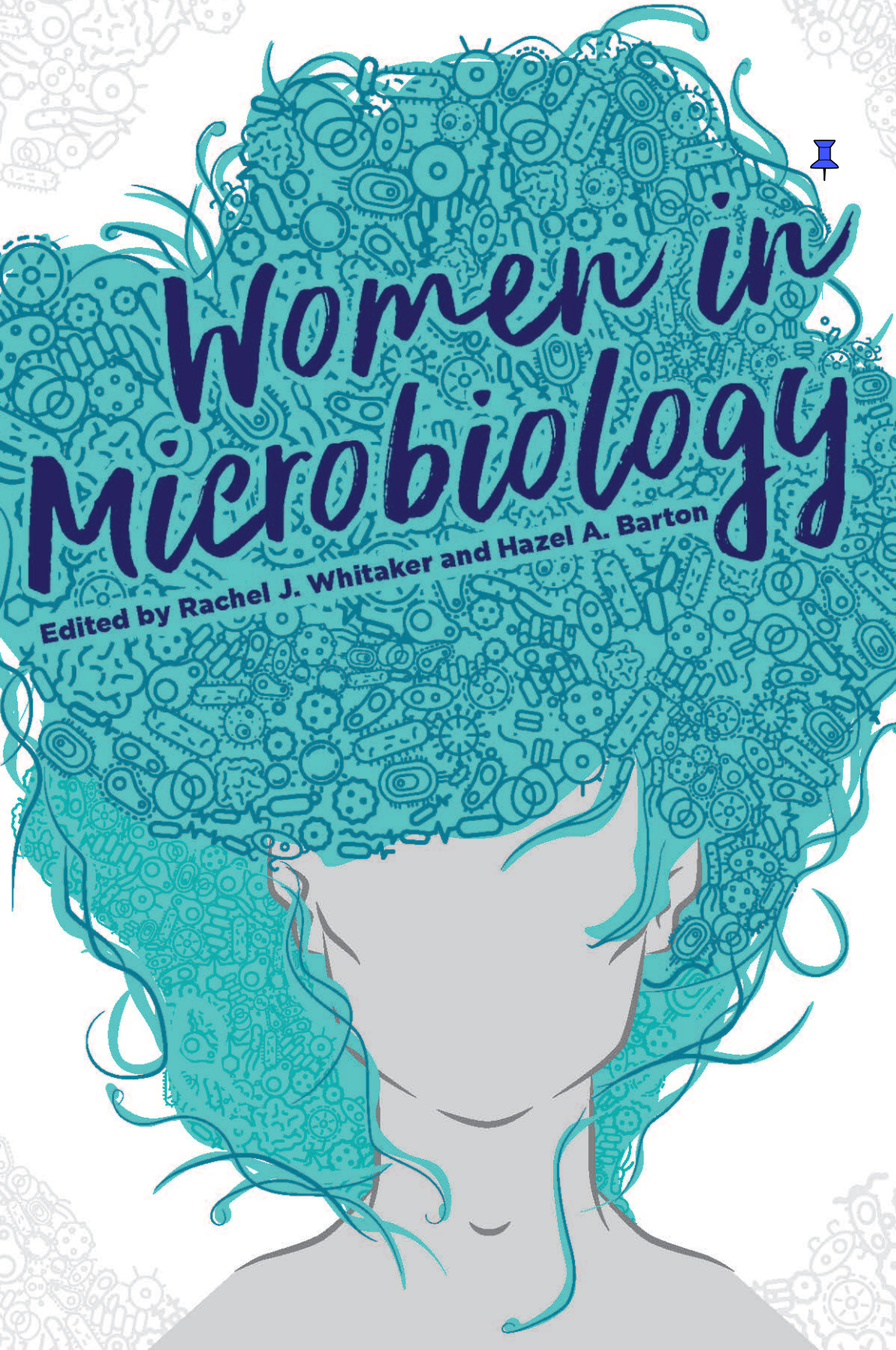




Women in Microbiology

Edited by Rachel J. Whitaker and Hazel A. Barton

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*Dedicated to the memory of
Congresswoman Louise M. Slaughter
(August 14, 1929–March 16, 2018)*

*Congresswoman Slaughter, a microbiologist,
was a powerful voice in the world whose career,
like many of the women profiled in this book,
took her in many directions.*

*She served in Congress from 1987–2018,
where she was a champion of women's rights
(coauthoring the Violence Against Women Act)
and a strong advocate for science, both in terms of funding
and the inclusion of women and minorities in scientific studies.*

*We are so grateful that she provided the
foreword for this book and hope that, in addition to
honoring the women microbiologists featured herein,
this book also serves as a memorial to Louise's legacy.*

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Foreword

The institutionalized problem of the disparity in the number of women versus men working in positions of power is no less cogent to the field of microbiology as it is to engineering, entertainment, and even the political sphere. As a policy maker and the only microbiologist in Congress, I have highlighted the importance of issues that touch or are touched by microbiology, from the critical growth of antibiotic resistance, to development of greener energy technologies, the importance of public health efforts, and advocacy for women's rights and equality in the workplace and elsewhere. *Women in Microbiology* is a beautifully written contemporary work covering both women throughout history who have advanced and impacted the field of microbiology, as well as women who are current leaders in the field. Some of the names are familiar and some are lesser known, but all of the stories serve to arouse a sense of excitement, driven by tales of new, important scientific insights, stories of overcoming adversity and breaking boundaries, and the inclusion of personal tips and advice from successful careers. Written by scientists, many chapters feature personal vignettes exemplifying how these women have taught, mentored, and inspired the authors through their careers. My hope is that this book will be broad-reaching, extending its inspiring stories to both men and women in the field of microbiology, and beyond. Microbiology is an area that touches all life as we know it, and I hope these stories touch your life in a very special way.

*Congresswoman Louise Slaughter
United States Representative
25th Congressional District
New York
January 2018*

Prefaces

In November of 2014, a small group of microbiologists gathered at a special symposium to celebrate Dr. Abigail Salyers, pioneer of human microbiome research, who had passed away the year before. Exciting ongoing science was discussed, but what made a lasting impression on me were the wonderful stories about Dr. Salyers as a person—the particular and often surprisingly strong and hilarious descriptions of her and her impact on our profession.

The next day, I met with Megan Angelini and Greg Payne from ASM Press to discuss ideas for potential new books. Moved by Abigail's story, I suggested a book profiling women in microbiology. We worked to develop the idea into a book focusing on women in microbiology who have had a positive impact on the field through their research accomplishments, their unique approaches to microbiology, or their actions as role models and mentors. Together, these chapters form a book that highlights the varied paths women microbiologists have taken to achieve professional recognition, explores their motivations as scientists, and considers the ways their lives have inspired others. We included both historical figures and active microbiologists, with names both familiar and less well known. Our hope was to write a book that would encourage current female scientists, inspire more women to enter the field of microbiology, and more widely share the diverse backgrounds and perspectives of these women. These were lofty goals, but as you will read, aspiring to lofty goals has often been key to the success of the women detailed here.

Against the advice of my mentors, colleagues, friends, and my husband, who feared it would take too much of the time I needed for other things, I agreed. That was three years ago and in a way they were right; creating this book was not an easy process. The hardest part was understanding that there was no way to make this compilation fully representative. There are many important, impactful, and inspirational women who are not included; along

with many outstanding colleagues who could have contributed additional chapters. We barely scratch the surface of the stories that could and should be told. Over time I grew to accept this, and I hope others will too, with the understanding that it is not for lack of dedication or commitment, but simply because this is such a big topic. There is inevitable regret and disappointment at what has been left out, but I hope readers will see this as just a starting point toward achieving the goals outlined above.

With these caveats, I think you will find this first book on women in microbiology to be an exciting and eclectic mosaic of stories. Each chapter is told from the perspective of its author, profiling a woman in microbiology from near or far, in time and/or space, and each has a different focus, motivation, and style. As I read these stories, I at times laughed out loud. I find myself motivated by the many different pursuits of these women. I am surprised at the barriers and misunderstandings that women scientists continue to face but I am also inspired by the diversity of ways strong women respond to them with humor and persistence. I reflect on which characteristics resonate with me and wonder what will make other readers laugh and whose stories they will find most compelling. Above all, what I take away from this compilation is the unique combination of intellect, insight, integrity, passion, and persistence that each woman profiled has brought to the field of microbiology. I wonder if there is something about scientific endeavor or about being a woman in science that somehow selects for, or generates, this combination of traits. For women in microbiology and in science in general, the sample size is still small. There is no one path, one style, or one contribution that defines women in science, and yet, from my read of these amazing stories it is the combination of these traits that unites them.

I am extremely grateful for all of the authors willing and able to take the time to reflect on and write about a woman in microbiology who inspired them. I am also deeply appreciative of the many people who wanted to contribute but were unable to at this time. I am grateful for the wide-ranging and uniformly positive responses to this idea which encouraged us to continue. In particular I credit Megan Angelini who generated the spark for this book and who kept the fire burning through tough times with positive encouragement and the integrity, passion, and persistence necessary for its completion.

—*Rachel J. Whitaker*

When I've told people I was editing a book on the contributions of women in science, the question I often got from male colleagues was [to paraphrase] "*Why only about women? That seems a bit unfair. You should do it about both.*" Yet no one mutters a word of objection when students are assigned textbooks that overwhelmingly highlight the careers and contributions of male scientists. This subtle bias in textbooks enforces the stereotype that the science of microbiology has been propelled forward by male scientists, with women relegated to supporting roles. It was time for a book that celebrated the role of women in microbiology.

Women obtain approximately 50% of all doctorates in biology, yet only 36% of Assistant Professors are women, a number that drops to 18% for Full Professors (1). The only place where women outnumber men in academia is in non-tenure track positions, where they hold 58% of the positions (2). There are many societal issues responsible for this disparity, and the potential solutions are certainly complex (1). One way forward is to encourage young women to see themselves as scientists; and once they can see themselves in that role, implement institutional changes to support and retain these women throughout their careers, with the opportunities necessary to attain high-level positions in academia, industry, and elsewhere. The purpose of this book is to profile women who have had a positive impact on the field of microbiology and highlight the many, diverse paths these women have taken to achieve professional recognition for their work.

Writing biographies that capture the motivations of women scientists has, historically, had varied results. On Twitter, Adela Torres (username @Daurmith) hilariously wrote the biographies of famous male scientists in the stereotypical way that many female scientists are written about: "*His dour personality made everyone think he'd never marry. Even so, Schrödinger got a wife and a Nobel Prize.*" This dichotomy highlights the way in which social

norms are perceived to play a greater role in the ability of women scientists to work, as if men were not equally subject to such societal pressure. In her critical review, Patricia Fara highlights the treatment of women in scientific biographies as *weird sisters*, the idea that any woman choosing a career in science did so as a misfit, or through choosing to sacrifice love and family, or (gasp!) at the cost of personal grooming (3). As Fara points out, given the disparity between men and women in science, such comparisons set scientific women apart and do little to encourage young women to see that it is entirely possible to have a rewarding scientific career, without the need to live as a multi-cat-owning spinster with frizzy hair and sensible shoes.

My coeditor Rachel Whitaker and I aimed to create a book exploring the interesting and inspiring lives of women in microbiology, helping to dispel common stereotypes and misconceptions for good. The biographies of women scientists in this book span almost 150 years, from the earliest studies of fungi under the microscope, through the microbiology of the Apollo moon missions, to the most cutting-edge environmental and computational science of today. The inspirational stories of these women are as variable as their science: there are those who inspired through a meticulous approach to science, others who demonstrated that it is possible to juggle innovative science with a family, others who were hell raisers, and those who nourished the creative talents of their students and helped them reach their full potential. There is as much breadth in our authors as the women they profile in terms of race and gender. After all, it is not solely the purview of women to be inspired by a female scientist, nor is such inspiration restricted in race.

We attempted to highlight the stories of women who found rewarding careers as microbiologists through a series of biographies chosen by the authors themselves. We asked, “Who inspired you, and how?” While it would be expected that a book such as this should feature the usual suspects of very famous women scientists, inspiration is a personal thing; some of our authors chose women who are indeed world famous, prize-winning scientists, whereas others chose women who drove change in scientific culture. Many chose women you might not have heard of but you may be thankful that you have now been introduced.

If we had highlighted every scientist we wished, this book would be far too long to publish. All of our authors are working professionals, and sitting down to compile a biography can be time consuming; for every three people we asked, two turned us down due to other commitments. Many of our authors spent months writing, interviewing the person they profiled at length and often interviewing their subject’s family, collaborators, and students.

Some went to original archives or even visited the neighborhood where the scientist whom they profiled had herself received inspiration. It truly has been a labor of love and respect. As editors, we have hounded authors, with persistent (and probably annoying) emails. Despite the irritation of repeated, nudging requests, almost universally we received similar feedback: *"This was really a lot of work, but I'm so glad I did it. I have learned so much about X and what they accomplished, I am truly inspired. Thank you so much for the opportunity."*

We are honored and flattered that our authors would think to thank us; however, we owe a greater debt to them. I am truly grateful for the efforts and dedication of all the contributors, who have brought the stories of these truly inspirational women to life. I would also like to thank the staff at ASM Press, especially Megan Angelini and Christine Charlip, who made this book a reality.

We hope that the reader will be as inspired as we have been and see the hope, joy, and beauty in the stories of these women fascinated by the microbial world.

—Hazel A. Barton

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About the Editors



Rachel J. Whitaker is an Associate Professor of Microbiology in the School of Molecular and Cellular Biology at the University of Illinois at Urbana-Champaign and current leader of the Infection Genomics for One Health research theme at the Carl R. Woese Institute for Genomic Biology. Her research focuses on the molecular evolution of cellular microorganisms and their viruses in natural contexts ranging from hot springs to infectious diseases. Dr. Whitaker and her lab seek to integrate microbial biology with ecological and evolutionary principles using genomics as a primary tool. Dr. Whitaker attended Wesleyan University in Connecticut where she majored in biology and the interdisciplinary Science in Society Program (SiSP). After college she worked as a VISTA volunteer and as a research technician before graduate school. Dr. Whitaker received her Ph.D. at the University of California, Berkeley working in the lab of John Taylor. She extended her work to environmental genomics during postdoctoral research with Jillian Banfield from whom she learned a great deal about working as a woman in science. Dr. Whitaker's research has been funded primarily by NASA and the NSF. She was recently the recipient of the Paul G. Allen Distinguished Investigator Award. She is excited to serve as co-Director of the Microbial Diversity course at the Marine Biological Labs in Woods Hole, MA from summer 2018–2023. Outside of science, Dr. Whitaker enjoys being a mom to two boys whose boundless energy and curiosity keep her engaged. She is most grateful to her husband who has supported her science, career, and life of adventures, to her parents who taught her to care passionately about equality, justice and education, and to the inspiring men and women she has worked with as students and postdocs.



Hazel A. Barton is a Professor and Director of the Integrated Bioscience Program at the University of Akron. Her research, geared toward understanding microbial interactions and adaptations to starvation in cave environments, has been funded by the U.S. National Science Foundation (NSF), U.S. National Institutes of Health, and the U.S. National Park Service. Dr. Barton also investigates the role the fungus *Pseudogymnoascus destructans* plays in the white-nose syndrome epidemic in bats, and has been funded in this venture by the U.S. Fish and Wildlife Service. Her research has been featured in *Sports Illustrated*, *Forbes*, *National Geographic Explorer*, *Outside*, *Science News*, *The Scientist*, *Popular Mechanics*, *Wired*, *Geo*, and *The Smithsonian* magazines; in the book *Extreme Scientists: Exploring Nature's Mysteries from Perilous Places*; on NPR and BBC Radio; on Animal Planet, the History Channel, National Geographic, the CBS Early Show, BBC TV; and in the IMAX movie *Journey into Amazing Caves*.

Dr. Barton is also an avid caver, having explored caves on six continents. She is a past director of the National Speleological Society, the Quintana Roo Speleological Survey, and an award-winning cave cartographer. Dr. Barton is currently a Fellow of the National Speleological Society, a Kavli Fellow of the National Academy of Sciences, Chair of the Committee on the Status of Women in Microbiology for the American Society for Microbiology, and the recipient of an NSF CAREER Award.

Bonnie L. Bassler: The Group Accomplishes More than the Individual

1

Nina Molin Høyland-Kroghsbo¹

THE BACTERIA WHISPERER

I was sitting, freezing cold, in an exceptionally large conference room in New Orleans at the 2011 General Meeting of the American Society for Microbiology. That year, Dr. Bonnie Bassler served as its president. I was especially excited for her talk. Finally, Dr. Bassler, also known as the “bacteria whisperer,” confidently walked on stage with her characteristic fast pace. She smiled warmly. She stood in front of a large screen depicting her favorite microbe, *Vibrio harveyi*, a bioluminescent marine bacterium. With energetic gestures and contagious passion, she pointed to a slide showing a lonely bacterium swimming all by itself, releasing cell-cell signaling molecules called autoinducers. Dr. Bassler explained that at low cell density, the autoinducers float away and the bacterium acts as an individual. Next, she pointed to a group of bacteria, all producing the autoinducers. “The bacteria grow in number, and since they all participate in making autoinducers, the extracellular concentration of the signal molecules increase in step with increasing cell number. When the molecules hit a certain threshold level, it tells the bacteria that they have neighbors, and, in synchrony, all of the bacteria turn on light production.” She could barely contain her excitement for the little critters. Her eyes sparkled as she described how, via a process called quorum sensing, many species of bacteria use different chemical languages to work together like multicellular organisms to accomplish amazing or terrifying things, depending on the bacterium. As the information soaked in, I was certain that I was finally in the right place in science.

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know, Albert, if I had not been committed to my University of Kentucky scholarship in 1940, I would have accepted the Rutgers scholarship that you subsequently received, and I would have discovered streptomycin.” With her quip, Hutchison spoke openly about the fact that hitting the antibiotic jackpot had involved luck: screening for new antibiotics was a soil sample isolation lottery, and all members of the group had been playing the same high-stakes scientific game. The fact that only one of them would win the top prize did not detract from the thrill of having been part of the action.

SUMMARY

Too often, we rely on the “great man” version of scientific advancement wherein a single brilliant leader who inspires and directs the work gets most of the acclaim for advances made by others. Anyone who has ever worked in a laboratory knows that most scientific developments are based on sustained cooperative work, not the work of a lone genius. In his autobiography, Selman Waksman compared himself to the conductor of an orchestra. Few accounts give much, if any, credit to the women who also were active participants in the Waksman laboratory or mention the way in which World War II had opened new doors for the careers of women in microbiology. The war not only created a huge impetus for finding novel anti-infective drugs but also meant that most young men were directly engaged in military activities, serving as troops, which thinned the number of male students available to conduct research in university laboratories. Women were welcomed to the search for new antibiotics partly because their presence kept graduate programs from withering through lack of “manpower.” As always in history, women took advantage of their opportunity.

These profiles are part of our microbiological heritage. We hope our accounts of the lives of these female pioneers will help preserve their legacies. We also hope this book will inspire readers to look more closely at the history of other microbiological innovations and seek out the unsung women—and men—who were participants. Almost without exception, every laboratory group has members (“*Hidden Figures*”) whose contributions are minimized or overlooked. Too often, the overlooked members have been women and minorities, yet synergistic collaborations, based on the unique strengths and contributions of different people, create the climate that leads to breakthroughs in microbiology and all of science. It is time we celebrate the women who were the hidden figures during the golden age of antibiotic discovery.

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