

is likely why so many are struggling to find relevance in today's nimble world of digital media and online education. Sure, the Internet requires some work to sift out reliable sources, but its conveniences and ubiquity are continuing to win out over printed text. As you surely know, this trend has made its way into classrooms too, where a single resource is less common than ever, and teachers are being asked to assemble courses all their own. Now back to that textbook you are imagining. Do you really want to invest yourself and your students in it? Dmitry Kondrashov's *Quantifying Life* makes a compelling case that in spite of all of this, you really should.

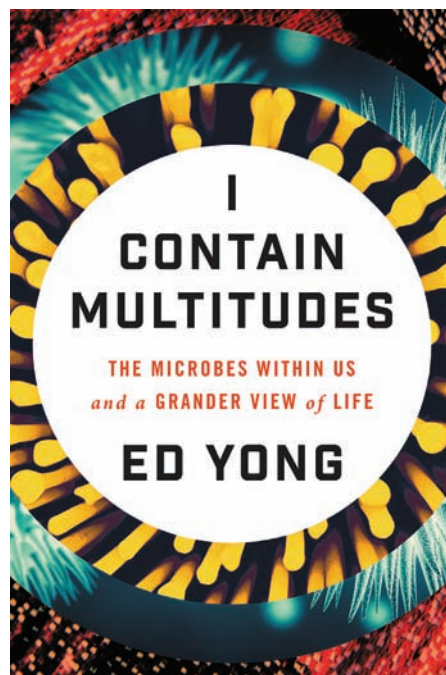
Let's step back for a moment, to the spring of 2013, when famed biologist E. O. Wilson published an essay in the *Wall Street Journal* with the punchline that "discoveries emerge from ideas, not number-crunching." He touched a nerve, mine included, in arguing that scientific and quantitative intuition are not only distinct, but should be fostered separately. *Quantifying Life* begins with the words of Siddhartha Mukherjee: "science begins with counting." If you too believe that the descriptive nature of science is inherently quantitative, and want to begin exploring what that really means, I implore you to give Dmitry Kondrashov's symbiosis of computation, mathematics, and biology a chance.

Weighing in at just over 400 pages, *Quantifying Life* manages to feel more like a novel than a textbook in your hands. And to my delight it reads more like one too, somehow managing to be conversational and approachable without sacrificing rigor. It is divided into four general sections, each involving tools to quantify more complex forms of life than the last. Kondrashov first tackles single variables, from simulating random numbers to plotting their dynamics, before scaling up to relationships between variables. The final two sections are devoted to entire systems of variables and understanding their behaviors, first with chains of variables moving discretely through time, and then finally as differential equations that describe variables changing continuously. Each of these is in turn divided into chapters with their own sets of learning goals and hands-on programming exercises to grapple with. All together these sections feel like a traditional textbook, but references between chapters act more as interesting connections than prerequisites. In this way *Quantifying Life* can serve as that first reference you reach for when your brow furrows just as easily as source material for that quantitative unit you've always wanted to teach. And for those just looking to curl up with a good read, its cadence and refusal to turn into dense blocks of text or incomprehensible equations will quickly have you lost in thought, conjuring up models of life and tests of reality.

Dmitry Kondrashov has written a Jack-of-all-trades textbook that is as interdisciplinary in its approach to education as it is in its broadly interdisciplinary subject matter. Most wonderfully, this remains true for more than just teachers. Are you a high school student looking to connect the dots between your science and math classes? *Quantifying Life's* gentle from-the-ground-up approach to integrating programming and mathematics with biology is just what you've been searching for. Are you a graduate student in the life sciences feeling that ever-stronger pull toward quantitative methods? *Quantifying Life's* intuition and application-oriented approach can help embolden you to bring statistical and computational rigor into your research. Or are you just secretly jealous of modelers you read about, always churning out equations and code, but get anxious at the thought of teaching yourself basic statistics? Again, *Quantifying Life's* conversational tone and unpretentious style can help ferry you through the foundations of modern modeling without you realizing how advanced the topics actually are. Most miraculously, no matter how you come to this book, it feels coherent and on point, somehow avoiding becoming a master of none.



Ryan E. Langendorf
 Doctoral Candidate
 University of Colorado, Boulder
 397 UCB Boulder
 Colorado 80309
 Ryan.langendorf@colorado.edu



I Contain Multitudes. By Ed Yong, 2016. Ecco/Harper Collins Publishers. (ISBN: 978-0-06-236859-1). 368 pp. Hard Cover. \$27.99.

"About microbes & quoting Whitman, 'I Contain _____.'" was the \$2000 clue in the "Complete the Title" category on the January 2, 2017, episode of television game show *Jeopardy*. Contestant Katie Carter's correct answer was "Multitudes." Having just started to review this book, I realized that its reference on the show indicated that it had already become a part of our literary culture.

Throughout most of its history, Earth's only life was microbial. Today we tend to think of nature as a vast and diverse interactive collection of plants and animals all over the planet. Actually, we share Earth with uncounted numbers of microbes, from the deepest ocean trenches to the clouds in the sky. There are more bacteria in a human gut than stars in our galaxy. People often hold the stereotype that all microbes are germs, signs of filth, and sources of dreadful diseases. Most, however, are non-pathogenic, and many are valuable to us. Numerous species exist in symbiotic relationships with the bodies of plants and animals and are the rule rather than the exception. Scientists now realize that, instead of focusing on solitary organisms, microbes must be studied as "communities living in habitats," specifically host organisms.

This book could change the way we think about microbes by unlocking a wealth of fascinating information on ways they are involved in the lives of animals. A sample of just a few things that most people don't realize about microbes might include the following. Bacteria help maintain the blood-brain barrier by forming cell clusters that block large molecules and living cells from passing into the brain. Microbes convert some insects from one gender to another. In humans, the villain-hero *Helicobacter pylori* causes ulcers and stomach cancer but protects against esophageal cancer. For a baby to get the most nourishment from breast milk, the bacterium *Bifidobacterium infantus* must be present. Tropical diseases like elephantiasis and river blindness are caused by nematodes, but it is the symbiotic bacteria released from the nematodes that trigger the immune response in the host, producing the disease symptoms. Many gut microbes involved in digestion contain genes swapped with other species through horizontal gene transfer. Changes in the human microbiome may be involved in obesity, allergies, kwashiorkor, marasmus, and inflammatory bowel disease (IBD). The immune system is not directed by genes alone, but microbes help to shape it and

even participate in its operation. Even our homes have distinctive microbiomes, mostly due to the microbiomes of the people living in them.

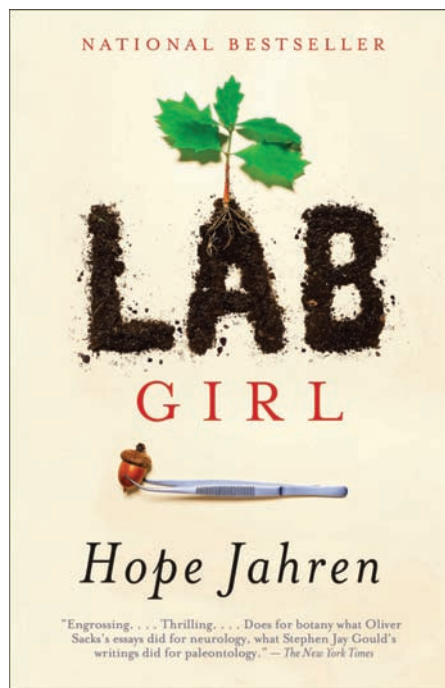
Beginning with Leeuwenhoek, the first human to see bacteria, Yong's story continues over four centuries to the present with his account of recent successes such as the use of fecal microbiota transplants producing phenomenal results in patients with stubborn digestive problems due to *Clostridium difficile*. He also comments that, as the book was going to press, clinical trials were beginning for a new multi-microbe treatment for IBD. He notes that microbiologists "find themselves racing to rewrite the relationships between microbes and their animal hosts." In his final chapter, "Tomorrow the World," he leaves the door open for the reader to peer into the future and consider what could be coming next. Yong sees great potential for microbiome medicine. He notes that different human microbiomes can actually influence the actions of medications from acetaminophen to digoxin to cancer drugs. He envisions a future where medical treatments might involve custom-made bacteria that will interact with the body's immune system and normal microbiome to tackle many medical issues. The unavoidable conclusion that one might make after reading this book is that "Microbes Rule!"

Yong tightly packs much significant content into the pages of his book. Sometimes, following a particular segment, the reader is almost compelled to pause, reflect, and process what s/he has read and consider whether they might need to reread it. He has researched his subject extensively and communicates his findings in a vivid and richly engaging writing style that, for the reader, is more like reading a well-crafted novel than a brilliant scientific treatise. Complex information is explained in lucid language, often with clever wit and the use of perceptive analogies. He is meticulous in citing his information and explanations in 29 pages of detailed endnotes and a 40-page bibliography. A comprehensive index is also included.

This book would be a valuable asset for the library of any high school or college biology department, where instructors would be well-served to become familiar with the information presented. It could change the way that microbiology, ecology, genetics, evolution, and other areas of biology are taught. Serious biology students would also find the book a valuable resource.



Richard Lord
Retired Biology Teacher
Presque Isle High School
Presque Isle, ME 04769
rmlord@aol.com



WOMEN IN SCIENCE: BOTANY

Lab Girl. By Hope Jahren. 2016. Alfred P Knopf. (ISBN 978-1-101-87493-6). 282 pp. Hardcover. \$26.95.

Anecdotal evidence suggests that every biologist who pursues a doctoral degree spends the first thirty minutes of each family event trying to answer some form of the question, "Why are you still in school?" Hope Jahren's delightful book answers the question nicely: Because scientific research is complicated, and studying living things takes time and patience.

Jahren's book is laid out in alternating chapters of memoir and ecology trivia. Even though the topic is definitely scientific, the prose is that of a fiction novel, so the reader is easily drawn in to the story. The book follows Jahren's educational and career journey through an entertaining personal narrative. Much of the book describes the evolution of her close friendship with her lab partner and provides a sort of love note to their friendship.

The first chapter of the book describes her emotionally isolated upbringing dominated by frigid Midwestern winters. Jahren describes spending time in

her science professor father's community college teaching lab as the fondest memories of her childhood, and the indelible impression it made on her. She attributes the time she spent at the black lab benches, tinkering around on her own while her father did his work, as stirring a "deep instinct" to unleash her own inner scientist. Jahren spends a fair amount of time in the first chapter reminding us all why we love science and how each of us has created our own special home-away-from-home within our labs and classrooms.

Jahren writes beautifully, yet frankly, about her experience as a researcher. Maybe her writing resonates with me because I can relate so well to her experience as a woman in science. Jahren is able to write so descriptively about her experiences in the field and in the lab, and the challenges that she faces in a male-dominated field that some passages in the book elicited an emotional response from me. In Part Three, Jahren offers an honest reflection on her struggle to be respected and accepted by male scientists in her field. She writes, "In my own small experience, sexism has been something very simple: the cumulative weight of constantly being told that you can't possibly be what you are."

Jahren is also open about how her choice to pursue her career challenged her own notions of womanhood. After a long night in the lab that led to her first independent discovery, she finds herself waiting for the sun to come up so that she can share the news with someone. The fact that she did not have a partner to share the news with made it a very lonely wait. She writes, "The realization that I could do good science was accompanied by the knowledge that I had formally and terminally missed my chance to become like any of the women that I had ever known." I think that scientists of both genders can relate to the personal sacrifices made in pursuit of discovery.

The middle chapters of the book discuss how difficult it is to fund scientific research and the struggle of securing grants. Jahren explains how hard it is to recruit and keep graduate students and lab staff in such an uncertain environment. In one passage, Jahren mentions that non-defense-related scientific funding has been declining steadily for the past 30 years. She counters the oft-repeated idea that the United States doesn't create enough scientists with the notion that there simply isn't enough funding to support the work of the scientists that U.S. colleges and universities are producing.

This book is entertaining and educational. Admittedly, I eventually began to rush through the chapters espousing the virtues of seed growth and the wonders of the relationship between root and