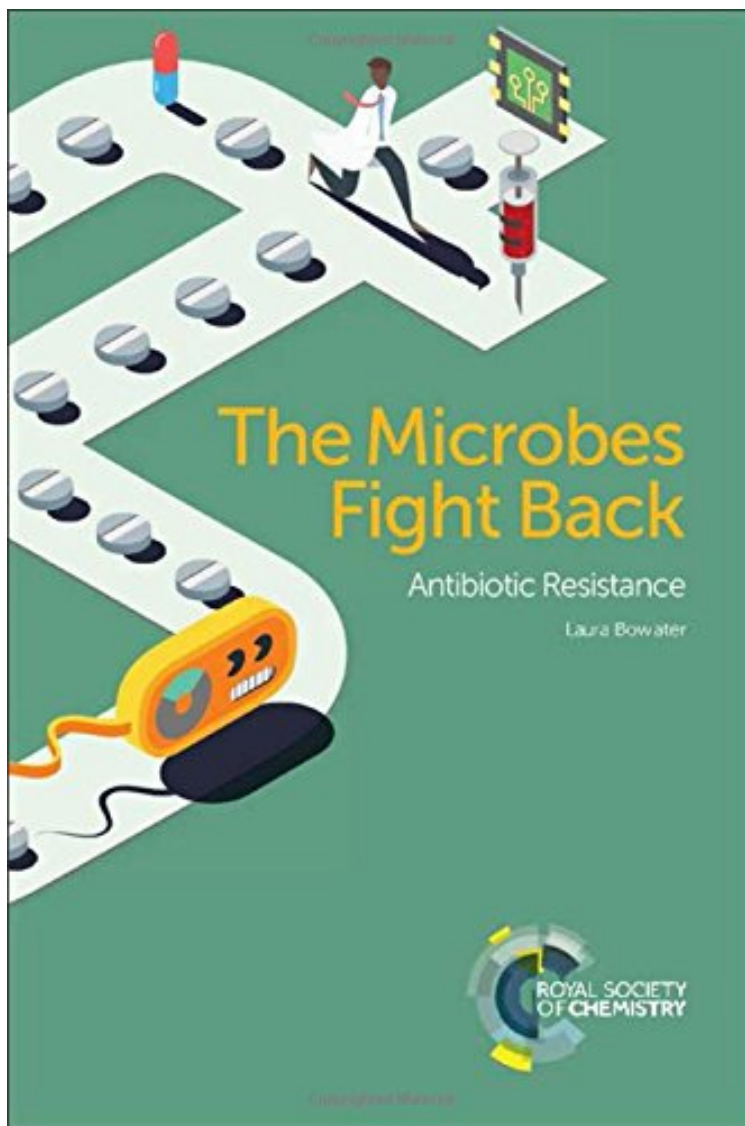


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The Microbes Fight Back: Antibiotic Resistance

Laura Bowater

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Laura Bowater : The Microbes Fight Back: Antibiotic Resistance before purchasing it in order to gage whether or not it would be worth my time, and all praised The Microbes Fight Back: Antibiotic Resistance:

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Antibiotics are familiar drugs to us all, so familiar that we may take them for granted. They allow us to survive life-threatening infections, and allow us to protect the animals we farm for food. Many antibiotics have now become ineffective against common diseases, and there are few alternative treatments to replace them. In this topical book, Laura Bowater, Professor of Microbiology Education and Engagement at Norwich Medical School, considers the past, present and uncertain future of antibiotics. This book begins by looking back at how infectious diseases, such as smallpox and The Plague, were able to wreak havoc on populations before the discovery of the first antibiotics. These then revolutionised the medical world. In an engaging and accessible style, Professor Bowater takes the reader through how antibiotics are made, how bacteria are able to mutate and develop resistance and she explains why there is now a lack of new antibiotic drugs coming to market. What will a future of continued antibiotic resistance look like? How can human activities prevent the rise of superbugs? Professor Bowater highlights the need for universal cooperation in order to tackle this global health challenge, which, if not addressed, could transport us back to the medical dark ages.

The world is awash with microbes. Move over, multicellular life. Microorganisms collectively amount to the largest biomass on the planet, and phages, viruses that infect bacteria, are the most abundant of Earth's many life forms. Microbes, tiny and ever-present, exist in their own ecosystems as well as participating in wider networks of living creatures. They have starred in a number of recent popular science books encouraging us to widen our vision of life. We humans, who have rampaged over much of our planet, are being encouraged to show some respect for life forms capable of thriving even in extremes of temperature and pressure, and chemically processing toxic metals for sustenance. We are becoming familiar, too, with the concept that our bodies are home to more microbial cells than human ones and that our health depends on their health. The older, antagonistic ideas of microbes as merely the unwanted causes of infectious diseases now seem dated. Enter Laura Bowater, a microbiologist and science communicator who shares the newly calibrated grander view of life but calls us to task for ignoring what is happening under (or perhaps in) our noses the continuing rise of antibiotic resistance and its implications for human health. It's a vital message. When my husband had his hip replaced, I was most frightened by the risk of biofilms, one of those fascinating ecosystems. The problem is that inside the body these aggregates of bacteria, held together by a matrix, can colonise the surface of a safely implanted prosthesis. May the surgical team keep everything scrupulously clean and may the routine post-operative antibiotics work, I said to myself. There seemed something disturbing, and very them and us, about an otherwise healthy individual's new implant being targeted by bacteria. As Bowater reminds us, the discovery and commercial production of antibiotics since the Second World War has underpinned much of modern medicine's techniques for keeping us healthy and functioning for longer. Going safely into the body to replace joints, transplant organs and carry out cancer therapies (with their unfortunate side-effect of immunocompromising the patient) are all made possible by antibiotics, and their continued success is threatened by resistance. Asked to name which of the infectious diseases that were once easily vanquished by antibiotics are now decreasingly so, it's almost a case of take your pick. In so many cases where we seemed to have control, that confidence is now under threat. Patients suffering from one of the great killers of all time, tuberculosis, face severe treatment challenges in many parts of the world because of drug-resistant strains of the causative bacillus. Similarly, those old diseases of the bedchamber, syphilis and gonorrhoea, the ones that we always find it so difficult to talk about, are becoming much harder to treat. Our children may well face risks that we had given up worrying about for a couple of generations. The probability of an Armageddon-like scenario, what it may mean and why it can happen are central to this book's message. It is to the credit of the publisher, the Royal Society of Chemistry, that it is keen to keep drug resistance in the public eye when there is severe competition for space on political and public agendas. It is an issue that is unlikely to feature in talks around Brexit or to get a mention in Donald Trump's anti-globalism pronouncements, but, as Bowater argues, international cooperation will be essential to tackling the threats of antimicrobial resistance. Bowater's style throughout *The Microbes Fight Back* is agreeably punchy, and the book's chapters are broken down into useful small, textbook-like chunks. In several boxed sections, microbiologists describe their current research. All this helps, because there's an inevitable upshift in the level of technical information that must be conveyed in the book's latter half. This is its strongest and most original part, as Bowater guides us through the fascinating structural and functional biology of micro-organisms, what exactly antibiotics are, how they work at the molecular level and why there is resistance at the genetic level. The chemistry of life is a wonderful thing, and we are steered ably through it. Authors always face the nagging worry of how well informed their intended audience will be, and given the recent upsurge in microbe-themed books, it is not easy to know how much background to provide. I pondered, when reading *The Microbes Fight Back*, just how much and what sort of history would be useful in analysing the current threat. I might have opted for a little less on the 17th-century microscopist Antonie van Leeuwenhoek and more on the recent discovery of 30,000-year-old bacterial DNA in the permafrost of Bear Creek in the Yukon. For all the ingenuity of Leeuwenhoek's lenses and his wonder at the colonies of bacteria that he saw in his tooth plaque, these sequences of ancient DNA hold a more potent message for today's problems. They reveal that resistance to the group of antibiotics

that includes the penicillins, tetracyclines and vancomycin was already encoded. Resistance is a natural phenomenon that predates our (over)use of antibiotics. As Bowater meticulously points out, this means that the dream of the magic bullet was always a false dawn, and resistance is a problem we will have to live with, no matter how clever we are. Its only very recently that we have begun to appreciate what this will mean in real life and real time, rather than in the laboratory where it was always known although there have been key transitions in perspective there, too. Microbiologists now no longer think of their study organisms simply as the pure cultures of the Petri dish, but are deepening their understanding of how microbes rub along together and coexist with other sorts of organisms. From this ecological standpoint, we can better explore the chemical roles and biological mechanisms of the naturally produced molecules that we have turned into drugs, hoping that knowledge itself is power. Looking at the environment shows us, too, that in addition to the threats posed by medical overprescription of antibiotics and their needless use in animal husbandry, their manufacture in regions where there is little regulation and hence cheaper production costs is also wreaking havoc with selection pressures. Samples of water from a lake in India polluted by the run-off from a chemical factory revealed a soup of bacterial resistance genes 7,000 times greater than in the control water elsewhere.

The Microbes Fight Back is a call for change. Bowater is optimistic that governments can legislate against antibiotics in farming and kick-start antibiotic research where drug companies have left the field. Quick and reliable point-of-contact testing for drug-resistant strains would allow for better-informed, appropriately conservative prescribing and would be a worthy winner of Nestlé's new 10 million Longitude Prize. We can play a part by not giving our GPs low satisfaction scores when they decline to give us the antibiotics that we should not have requested for a viral cold. As Bowater emphasises, however, all this is mere damage limitation. Resistance is part of nature, and all our efforts must be exercised not as a series of one-offs, but as constant features of the way we want to live.

Helen Bynum is honorary research associate in the department of anthropology, University College London, and author of *Spitting Blood: The History of Tuberculosis* (2012).

The Microbes Fight Back: Antibiotic Resistance By Laura Bowater
Royal Society of Chemistry, 302pp, 21.99 ISBN 9781782621676 Published 16 December 2016

The author Laura Bowater
Laura Bowater, professor of microbiology education and engagement at Norwich Medical School, University of East Anglia, was born in Birmingham, but lived on a science research station in Uganda until she was six. When Idi Amin came to power, she adds, her family was forced to return to the UK. Living in Uganda came with all sorts of rules: never drink water unless it has been boiled; always keep shoes on your feet; don't swim in the lakes; never eat fruit unless it has been washed or peeled, she recalls. At the time I saw these as unwanted constraints, and ones that I ignored with impunity. But as I grew older I realised that they had been set to protect me from catching unwelcome tropical diseases caused by the myriad of microbes and parasites that I couldn't see. Ultimately this led to my interest in microbiology. I wanted to understand how such tiny lifeforms could potentially cause such suffering. She was, she admits, absolutely not a studious child. But I was always an avid reader and could never source enough books to keep me going. I can't remember ever studying hard for exams, but I was reasonably bright, and my book reading gave me a good general knowledge that served me well. My father was a soil scientist, and in high school I realised that I was good at chemistry. However, I never encountered microbiology within the science curriculum I studied at school, and I am aware that I would never have chosen to study microbiology at university if it hadn't been for my own personal interest in the subject. Leaving school at 16 with a handful of Highers and an offer to study microbiology and biochemistry at the University of St Andrews, Bowater turned 17 during freshers week and spent her first year getting to grips with the fact that a lot of the science that I had been taught at school was incorrect. A decidedly unambitious student, Bowater adds that to some extent I was disappointed with the degree that I had chosen. In my eyes it focused on industrial microbiology and carbon and nitrogen cycles and medical microbiology wasn't a strong focus at all. In retrospect, I realise that my ideal degree would have been to study microbiology with public health, but I hadn't even heard of that as an area or a discipline until I left university. I am pretty sure that if you were to ask my lecturers at St Andrews, they would be as surprised as me to see that I am now a professor in microbiology education and engagement. My determination and drive for success arrived in my thirties and has surprised me more than anyone else. The debate over genetically modified food, she recalls, marked her time as a postdoctoral research assistant at the John Innes Centre in Norwich, and it was a spur to her growing interest in science communication. The John Innes Centre is a plant research institute, and both it and the scientific research that it was conducting were under attack. It was clear to me that as scientists we had done a pretty poor job of explaining what we were trying to do and why we were trying to do it. I also realised that a significant societal change had taken place. It felt as if, almost overnight, scientists were suddenly being viewed through a dystopian lens. The result was that scientists no longer had the luxury of conducting their own research in ivory towers; instead we became accountable to our funders, who were not just governments or charitable organisations but ultimately the general public. One skill I have developed is to learn from my own mistakes and the mistakes of others, and it was this experience that encouraged me to begin to communicate science effectively. What of the challenges to carrying out effective science communication, especially when coverage of complex issues in mainstream media is often oversimplified or inaccurate? Bowater replies: I have worked with science journalists from the Daily Mail and other media outlets, and in general, I have found them to be diligent in their research and ensuring that they accurately

portray the facts. I think the greatest challenge to carrying out effective science communication is assuming that it is someone else's job. It isn't! I guarantee that the process of distilling complex ideas and concepts into clear simple messages is an essential skill for all scientists. As a science community we should not feel afraid of democratising science. I am aware that a recent study suggested that making science easier to understand encourages members of the public to ignore expert advice, as they feel that they understand science. But if that expert advice has already been provided in an easy to understand message developed by experts and understood by the public, then what is the problem? In my eyes that is a successful outcome of years of hard work by an army of dedicated science communicators who have worked tirelessly to democratise science. Bowater's favourite audience as a science communicator, she says, is adults who may have thought science wasn't for them. Sparking their curiosity to learn more, or empowering members of the public to make their own informed decisions armed with facts, is personally rewarding. But this is a two-way process, and what I find equally valuable are the questions and the conversations that have made me challenge and reconsider my own ideas and points of view. If she could persuade the UK government to pass one piece of legislation aimed at helping to address antibiotic resistance, what would it be? This is a difficult question. I believe that some of the greatest positive changes to human health have been as a result of legislation that has focused on improving public health. My personal philosophy is that prevention is better than cure, and I feel that this has to underpin all legislative decisions focused on the growing problem of antimicrobial resistant infections. History has shown that disease prevention initiatives have transformed health. A commitment to invest in and empower public health prevention measures would be at the top of my persuasion list. What gives her hope? Scientific progress and human ingenuity. (Helen Bynum, University College London Times Higher Education) "Bowater describes the battle between public opinion and scientific fact, and the impact of public health policy on epidemiology. She also demonstrates again and again the part played by serendipity combined with astute scientific observation in early antibiotic discovery. Along the way there are interesting facts and stories and many personal anecdotes from active researchers in the field that add flair to the book." Aurora Walshe, Chemistry World, 11 February 2017 (Aurora Walshe Chemistry World) I remember watching the movie The Truman Show when I was a child and for weeks afterwards feeling paranoid that I was being watched. Reading *The Microbes Fight Back: antibiotic resistance* gave me a similar level of paranoia: microbes are everywhere! Bacteria, fungi, archaea and viruses are on furniture, fabrics and food. They are on us and in us. They're everywhere. This may be a slightly terrifying thought, but thankfully Laura Bowater explains that not only are many types of microbes completely safe, but some actually have significant value in nature and industry. The average adult human carries about 2kg of bacteria in their gut that aid digestion and help the immune system antibiotic use can inflict serious damage on this ecosystem; in fact, antibiotic use in infants can lead to lifelong increased risk of infections and inflammatory bowel diseases. This book is a thorough analysis of the history and origins of microbiology, and the roles of microbes in infectious disease. Bowater describes the battle between public opinion and scientific fact, and the impact of public health policy on epidemiology. She also demonstrates again and again the part played by serendipity combined with astute scientific observation in early antibiotic discovery. Along the way there are interesting facts and stories and many personal anecdotes from active researchers in the field that add flair to the book. *The Microbes Fight Back* sheds light on the variety of ways that human behaviour is contributing to microbial resistance, the challenges of finding and designing new antibiotics and the dire need for new technologies for rapid, point-of-care diagnostic tests to prevent prescribing antibiotics for conditions such as the flu or asthma. However, the impact of the overall message is lost in a level of detail in the discussion that is repetitive for someone familiar with biochemistry but could be an information overload for a beginner. And although the images and graphs are useful and relevant, they would be clearer and more impressive in colour. This book does highlight that microbial resistance is a global challenge and that we have a long way to go before we can, as US Surgeon General William H Stewart once said, close the book on infectious diseases and declare the war against pestilence won. (Aurora Walshe Chemistry World) Enter Laura Bowater, a microbiologist and science communicator who shares the newly calibrated grander view of life but calls us to task for ignoring what is happening under (or perhaps in) our noses the continuing rise of antibiotic resistance and its implications for human health... Bowater's style throughout *The Microbes Fight Back* is agreeably punchy... *The Microbes Fight Back* is a call for change. (Helen Bynum, University College London Times Higher Education) A fascinating and fantastic account of the history, science and most crucially the future of antibiotics. Whether you prescribe them or merely use them this is an indispensable read. (Dr Chris van Tulleken, BBC Science Presenter and MRC Research Fellow, University College London) This is a very readable and enjoyable book. It is broad in scope covering the first understandings of the microbiological cause of infectious diseases right up to the current crisis of antimicrobial resistance and possible solutions. These include infection prevention and control, alternative strategies and citizen science. There is also a section on the microbiome illustrating how use of antibiotics can give collateral damage. Something for everyone - from the interested public to students. (Professor Laura Piddock, BSAC Chair in Public Engagement and Deputy Director, Institute of Microbiology and Infection, University of Birmingham) From the Back Cover Antibiotics are familiar drugs to us all, so familiar that we may take them for granted. They allow us to survive life-threatening infections, and allow us to protect the animals we farm for food. Many antibiotics have now become ineffective

against common diseases, and there are few alternative treatments to replace them. In this topical book, Laura Bowater, Professor of Microbiology Education and Engagement at Norwich Medical School, considers the past, present and uncertain future of antibiotics. This book begins by looking back at how infectious diseases, such as smallpox and The Plague, were able to wreak havoc on populations before the discovery of the first antibiotics. These then revolutionised the medical world. In an engaging and accessible style, Professor Bowater takes the reader through how antibiotics are made, how bacteria are able to mutate and develop resistance and she explains why there is now a lack of new antibiotic drugs coming to market. What will a future of continued antibiotic resistance look like? How can human activities prevent the rise of superbugs? Professor Bowater highlights the need for universal cooperation in order to tackle this global health challenge, which, if not addressed, could transport us back to the medical dark ages.