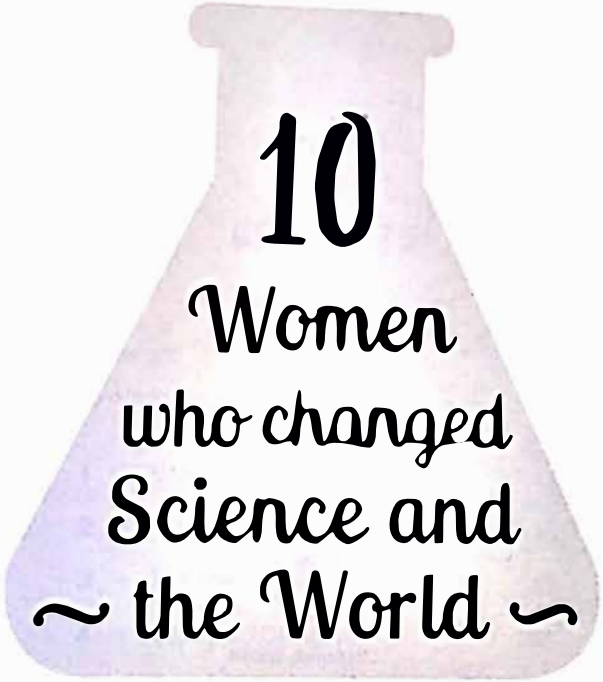

10 Women who changed Science and the World

CATHERINE WHITLOCK AND RHODRI EVANS

Foreword by
ATHENE DONALD, Professor of
Experimental Physics, University of Cambridge,
and Master of Churchill College

DIVERSION BOOKS

FOREWORD

IT IS OVER A CENTURY since the first woman received a Nobel Prize in science. In that time, since 1911 when Marie Curie received that accolade, only a further eighteen women have been likewise so honored (including Marie Curie who won it twice) and only a single woman in the UK has been so honored. When she was—Dorothy Hodgkin in 1964—did the press regard her in the same light as they would a man in the same position? Absolutely not. The *Daily Telegraph* announced "British woman wins Nobel Prize— £18,750 prize to mother of three." The *Daily Mail* was even briefer in its headline "Oxford housewife wins Nobel." The *Observer* commented in its write-up "affable-looking housewife Mrs. Hodgkin" had won the prize "for a thoroughly unhousewifely skill: the structure of crystals of great chemical interest." It makes for depressing reading fifty years later, but we have nothing more up to date to leaven the message. Two more women winning prizes in 2018 is a step in the right direction, but hardly proof that the situation is transformed.

Dorothy Hodgkin, featured as one of the ten outstanding women who have contributed so much to the world of science in this book, would not have had time to consider whether or not she was a feminist (although in later life she was very visibly a pacifist). She only wanted to get on with the job of what really interested her: the structure of biological molecules. As she put it, she just wanted to "live simply and do serious things," and serious things she most certainly

did, solving the three-dimensional structures of insulin, vitamin B12, and penicillin amongst other complex molecules. As a woman working in a man's world, she simply dedicated herself to achieving as much as she could and small matters like pregnancy were not allowed to get in the way. When married, but still working under her maiden name of Crowfoot, she presented a key paper at a major meeting at the Royal Society in 1938 when eight months pregnant. A long-term collaborator (and another Nobel Prize winner), Max Perutz, referred to her appearance at this meeting in his speech at her memorial service: "Dorothy lectured in that state as if it were the most natural thing in the world, without any pretense of trying to be unconventional, which it certainly was at the time."

In this book, her life and those of nine other remarkable women, including Marie Curie, are explored—women from around the world and from very different cultures and backgrounds. It is interesting to see what common features their lives share and what that might mean for young women growing up now. At the top level of sciences, particularly the physical sciences, there is still a dire paucity of women. Diversity—amongst Nobel Prize winners in particular, but also amongst the movers and shakers (and winners) in science—is still rather limited. The women chosen for this book are all dead, not living role models who might be seen on TV or interviewed in the press (let alone liked on social media): the authors felt that that distance provides perspective and understanding.

In the days before superfast global communication, these women's science and the impact they made often remained hidden and to a certain extent unrecognized, sometimes by their peers and almost invariably by the general public. Even in today's era of highly accessible information, their importance and impact are not well known. They and their work should be better appreciated because they were groundbreaking trailblazers, whether or not they would have recognized that at the time.

Luck plays a role in every scientist's life, whether or not they are prepared to admit it. In the case of Gertrude Elion it was her father's

suggestion that—after repeatedly failing to get even as far as job interviews after obtaining her MS in chemistry—she ring up Burroughs Wellcome, simply because he was familiar with the company because they made a painkiller he used in his dental practice. There, Elion quickly found her feet and stayed for many years researching novel "designer drugs," for which she ultimately won the Nobel Prize in 1988. The Chinese-American physicist Chien-Shiung Wu said of her own work that "Relying purely on ingenuity, determination, and luck, three of us (an enthusiastic chemist, a dedicated student, and myself) worked together uninterruptedly to grow about ten large perfect translucent CMN single crystals by the end of three weeks." Growing crystals of complex molecules is something of a black art, which is why luck enters into it. But she was also unlucky in that the Nobel Committee overlooked her strong credentials; she enters the group of women—to which Lise Meitner from this book also belongs—who are so often identified as those who did *not* win a Nobel Prize when they were more than deserving. Here, lack of luck in the lottery of winning big prizes also enters into the dimension, along with the bias often attributed to the Swedish committee.

The determination Chien-Shiung Wu mentions is also a crucial character trait absolutely required for success for anyone in science. Determination is often epitomized by the hard work that Marie Curie, with her husband Pierre, put in to extract from the bulk mineral pitchblende the trace components of the elements ultimately known as thorium and polonium that give rise to high levels of radioactivity, levels she recognized as being much higher than that due to uranium alone. Marie Curie is of course *the* female scientist that most members of the public are likely to be able to name and the only woman accorded the honor of two Nobel Prizes, one in Physics and one in Chemistry.

Rachel Carson was another woman who exhibited enormous determination to bring her concerns about environmental pollution to the wider public, however much this steeliness may have been hidden behind a quiet exterior. Without this strength of mind coupled with

beautiful writing skills, it is unlikely that the dangers associated with pesticides such as DDT would have been recognized—and acted upon—anything like as fast.

Above all else, though, scientists must harness their creativity and imagination. Research and discovery necessarily require a plunge into the unknown. If the answers were already known then there would not be any research to do. Not everyone is cut out to cope with such uncertainty and unfamiliarity, but the ten women discussed here all possessed the curiosity and willingness to attack a blank sheet of paper with gusto and guts. The results they obtained changed the world of science, whether or not their names are familiar in our daily lives.

These women overcame all the many obstacles their gender placed in their way to produce breath-taking results of profound significance, work whose importance still echoes today. We should be grateful to these pioneers and, without sentimentalizing their lives, we should appreciate all they did to facilitate the female scientists who have followed in their footsteps. As the L'Oréal tagline puts it, "The world needs science and science needs women." The lives of the ten women described here provide us with much food for thought and perhaps inspiration for the budding scientists of tomorrow.

Athene Donald,
Professor of Experimental Physics, University of Cambridge,
and Master of Churchill College

INTRODUCTION

"OXFORD HOUSEWIFE WINS NOBEL" would not pass muster as a politically correct headline these days. Notwithstanding the inherent sexism in the choice of words, receiving a Nobel Prize does not determine how successful a scientist you are, nor is it something many scientists set out to achieve. Certainly Dorothy Hodgkin, about whom the *Daily Mail* wrote that headline in 1964, was far too busy getting on with the job at hand—probing the structures of complex biological molecules—to be focused on either prizes or headlines. She did not see herself as a feminist or consider too deeply how she was defined. Dorothy was, in her own words, a woman who chose to "live simply and do serious things." This was an understatement: she worked extremely hard at a subject about which she was passionate, enjoyed a long and sometimes demanding marriage, had three children, suffered from crippling rheumatoid arthritis, and played out a humanitarian role on the world stage.

All in a day's work for Dorothy, so she was a natural choice for inclusion in this book. Others required a bit more consideration. Was it important to choose women who had children in order to suggest that women could have it all? Or was their science the most important thing about them? Delving into their family lives was only one facet of their story in science. And their scientific lives are, after all, the focus here.

In deciding on our ten, we chose women who are no longer alive. That was mainly because distance brings their achievements into focus. Many of these women were not well-known in their lifetime and, in the days before Google existed, finding out about them would have been harder. Nowadays, the news of the 2018 Nobel Prize winner in Physics, Donna Strickland—only the third awarded to a woman—was spread worldwide within seconds of its announcement. Only one of our choices, Marie Curie, is a household name. We could have chosen to omit her, as she is so well known, but her work on radioactivity was vital, considerably advancing the field of nuclear physics, and she serves as a benchmark for others. Needless to say, the women in this book are more than a match for her.

It's not easy to narrow down to a list of ten, even in the relatively small pool of influential female scientists. Ten seemed a good round number to pick—large enough to provide some breadth but small enough to allow depth, too. We have tried to introduce as much variety as possible, to provide a broad picture of the impact these pioneers have made. These women worked in very different areas of science: some lab-based and highly technical, others in medical science or in the environment. There is an international flavor here as well, with American, British, Chinese, Italian, and Polish scientists represented.

Not only did these women work in very different areas but they were very different characters, too, from the shy Lise Meitner and the retiring but persuasive Rachel Carson to the more outgoing, sociable Virginia Apgar and the strong-willed Rita Levi-Montalcini. It takes all sorts to be a successful scientist. That said, there are some common themes that run through their personalities, science, and lives.

All of these women were born within approximately fifty years of each other, with the majority born in the twelve years between 1906 and 1918. As the Victorian industrial age opened up a technological front, they lived through a period of great change, both in the scientific world and from a historical perspective. Two world wars, the financial deprivation of the Great Depression, and the Cold War made huge impacts on their lives and working conditions.

Working conditions were often very tough. The name of the game here was exile—from their countries (Lise Meitner), within their countries (Rita Levi-Montalcini), or "just" from the male-dominated environments of their era, including lecture halls or the facilities upstairs (Henrietta Leavitt). Where lab space was provided, it was often very cold (Marie Curie) or very hot (Gertrude Elion) or lacking in the most basic health-and-safety measures (Marie Curie and Dorothy Hodgkin). Their work was frequently physically and/or mentally draining.

There were upsides. All of our scientists lived in an age where they didn't have to justify their research in the same way as is required nowadays. No impact statements were necessary. Pure research was just that and they were often much freer to push the boundaries in whichever direction the research led.

Inspiration came frequently, initially in the form of family influence because the parents propagated an intellectual environment and/or because the older generation, particularly the mothers, felt that they had missed out on an education and a career. Family support—both moral and financial—was key, often into adulthood. The home environment and personal experiences also drove some of these women. Rachel Carson's rural idyll and the threat from local industry permeated her later environmental research and writing, while the illness and death of close family and friends propelled Virginia Apgar, Rita Levi-Montalcini, and Gertrude Elion into medical research. Later in life, teachers, university lecturers, or close colleagues frequently provided the spark that ignited their interest.

Some characteristics are common to all these women: an early, insatiable appetite for learning; persistence—a certain terrier-like mentality; experimental precision; fierce intellectual focus; drive; and intuition. These threads are woven throughout their stories and undoubtedly contributed to their scientific success. It's likely that none of these women would have set much store by analyzing the relative merits of these characteristics, nor were they self-publicists. They were too busy doing their science and many, such as Elsie

Widdowson, reasoned that no one would be interested in their story. Only one, Rita Levi-Montalcini, wrote an autobiography, wryly titled *In Praise of Imperfection*, and that was, in part, achieved because she lived until she was 103 years old!

Many of these women had a very personal approach to science, sometimes at odds with the formal attitudes of their time. Dorothy Hodgkin insisted that everyone in her lab was called by their first names, something that we have adopted for the women in this book. And Dorothy, like Marie and Rita, was not averse to, and indeed encouraged, positive discrimination in her laboratory. Passing on knowledge is a constant theme, too, with scientists like Virginia and Gertrude consistently praised for their teaching capabilities and a warm, engaging approach to their students.

It's easy to slip into hagiography when discussing these women but they certainly weren't saints. Chien-Shiung Wu was frequently described as a "slave driver" by her laboratory staff and her parenting skills were questionable at times. Rita Levi-Montalcini was not known for suffering fools gladly and her argumentative nature frequently got her into trouble. But the facts speak for themselves. These were ordinary women who, often via rather circuitous routes and not without their fair share of mishaps, disasters, and family tragedies, did extraordinary things.

A significant number of our scientists had such strong working partnerships that they were married to a particular colleague in their science, and in life in the case of Marie and Pierre Curie. For most, a shared passion did not necessarily extend beyond the laboratory, but some scientific partnerships were so successful that they remained close collaborators for many years, sixty in the case of Elsie Widdowson and Robert McCance. Lise Meitner and Otto Hahn's story was of a more tortuous, unbalanced relationship but, despite this, their joint scientific legacy has stood the test of time. Gertrude Elion and George Hitchings shared an ability to develop a personal relationship with their cancer patients and design radically different drug treatments. Rita Levi-Montalcini and Viktor Hamburger were also

equally involved in their science, but partnerships like theirs often encompassed quite different mindsets; Viktor's incremental approach to scientific research complemented Rita's more flamboyant style.

The social context of science is important, and none realized this more acutely than Lise Meitner when she discovered that her research was going to be used to make an atomic bomb. Women like Lise Meitner and Marie Curie were brilliant scientists but they were outsiders, let in reluctantly, often working beyond the walls of the establishment. That put them in a strong position to question and address those issues that others toeing the line could not. Their viewpoint and experience were different. They were open to questioning the processes. Where was the science leading and were the scientists involved guiding that process effectively?

Dorothy Hodgkin was a lifelong promoter of science nationally and internationally. At a time when the Cold War, and the rise of communism, was influencing and hampering scientific research in countries such as China and Russia, she built scientific relationships and kept the lines of communication open. She shared this humanitarian streak with others. Lise Meitner, Marie Curie, and Rita Levi-Montalcini worked to help the sick in the two world wars, frequently in distressing and humbling conditions and often using their scientific backgrounds. Rita Levi-Montalcini continued throughout her long life to promote the cause of women, in particular women's education.

Science doesn't work in a vacuum and engaging the public is vital. Many of our ten women were aware of the public interest in science and were keen to reach out to others. Rachel Carson's views sum it up well: "We live in a scientific age; yet we assume that knowledge of science is the prerogative of only a small number of human beings, isolated and priest-like in their laboratories. This is not true. The materials of science are the material of life itself. Science is part of the reality of living; it is the what, the how, and the why of everything in our experience."

In an ideal world, a book like this would simply illuminate what interesting scientific lives these women led and any push to correct

the gender imbalance and inspire young scientists, particularly women, would fade into the background. For now, we hope that by turning a spotlight on these ten women's experiences of science, and the differences they made to the world, this book will serve as a reminder of what is possible for women in science, with determination, direction, and focus.