

## Unsung Women in Science

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*Five of the most amazing women you've never heard of.*

### **Kati Kariko**

*Science for its own sake*

Asked to name an important woman scientist, most people will mention Marie Curie, and with good reason. But how many will even know about Kati Kariko, who also seeded a whole branch of science that, every day, changes the lives of millions of people around the world and, like Dr Curie's discoveries, will continue to do so well beyond her lifetime.

This daughter of a butcher grew up in 1960s Hungary knowing she wanted to be a scientist, even though she had never actually met one. And what a scientist she became, laying the foundations of the mRNA technology at the heart of the Pfizer-BioNTech and Moderna vaccines that are being jabbed into arms around the world each day, saving millions of lives and doing more than anything else to help us recover from the blight of Covid-19.

Like Marie Curie, Kati Kariko pursued science for its own sake. That is just as well, because the life of a full-time researcher is no less precarious now than it was in Dr Curie's day.

With a PhD, some experience as an experimental researcher and less than \$1,500 in cash, accompanied by her husband and their two-year-old daughter, she moved to Pennsylvania as a post-doctoral student at Temple University when lack of funding at the University of Szeged had forced its research programme to close.

Her work on mRNA began in 1990 with Dr Elliot Barnathan, then a cardiologist at the university, when mRNA was about as unsexy as it gets. They made it sexy when they found that inserting mRNA into cells to instruct them to make specific proteins worked even better than they dared hope, with their results suggesting that mRNA could be used to instruct any cell to make any protein at will.

This was powerful stuff, but funding was as unreliable as ever, and Dr Barnathan left the University to work at a biotech firm, leaving Dr Kariko without financial support. She was granted funds to establish mRNA-based gene therapy and was anticipating a full professorship when the money ran out again and she was demoted. Her persistence paid off though, and in a series of articles from 2005, with Dr Drew Weissman, she described the role of mRNA in reducing immune reactions.

Perhaps the value of those insights was not as clear as it is now, for the University of Pennsylvania sold the intellectual property to a laboratory supply company; so that when Dr Kariko was approached by a financial backer of Moderna, she had to report that she no longer owned the rights to her own ground-breaking insights.

Realising that research at the university would always be precarious, she went to work for BioNTech, a German firm, with more secure funding, eventually, as we know, from the EU, amongst others, to deliver not just the Covid-19 vaccine, but know-how that may well lead to more effective treatments for cancer, influenza and much more, thus turning an unloved corner of science into one of its most promising fields.

Marie Curie is certainly an inspiration, but other women working in fields closer to her own also laid important foundations: women like Rosalind Franklin.

### **Rosalind Franklin**

*Too coolly superior*

Largely unrecognised during her short life, from 1920 to 1958, Rosalind Franklin may well have been the first to describe the structure of DNA. Certainly, her work on this very subject was used but neither correctly attributed nor acknowledged by Nobel laureates James Watson and Francis Crick.

After the war, with Jacques Mering at the Centre National de la Recherche Scientifique (CNRS) in Paris, she used X-ray diffraction to study amorphous substances, obtaining results that still underpin mainstream research in the subject. In 1950, a three-year fellowship at Kings College, London, saw her working in the Medical Research Council's Biophysics Unit. John Randall, its head, directed her, as the only experienced experimental diffraction researcher the unit had at the time, assisted by graduate student Raymond Gosling, to build on pioneering work by Maurice Wilkins on DNA fibres.

Applying what she had learned in her wartime work studying the porosity of coal and refining the equipment at hand, she described, in a lecture delivered at Kings College in November 1951, a 'helical structure...containing two, three or four co-axial acid chains per helical unit...'

Clearly, she was on to something and published a number of important results as she continued her experimentation. Too cautious to announce conclusions without complete and convincing results, it was only on 6 March, 1953, that her results on the structure of DNA were lodged with Acta Crystallographica in Copenhagen. At that point, the Cambridge team, James Watson and Francis Crick, had only just started work on the structure of DNA, in which they drew on crystallographic calculations published by Franklin in December 1952, but which they mention only in a footnote, as 'general knowledge of' Franklin and Wilkins. Watson and Crick completed their model of DNA on 7 March, a day after Franklin's work had already been received in Copenhagen.

Maurice Wilkins, who disliked Franklin's 'air of cool superiority', wrote to Watson and Crick in early March to inform them that Franklin had moved to Birkbeck College and that they could now put 'all hands to the pump' to advance their work, which they published on 25 April.

She continued her research, now in RNA and the structure of the Tobacco Mosaic Virus, and, contradicting the results of the eminent virologist, Normal Pirie,

published, with Aaron Klug and his student, Finch, a series of seminal works on the subject, before moving on to work on the polio virus.

### **Cecilia Payne-Gaposchkin**

#### *Objective experimentation and an open mind*

Everyone knows that the sun and the stars are made of iron. Well, they thought they did until Cecilia Payne-Gaposchkin proved them wrong and, like Rosalind Franklin, outpaced established experts. Until then, all the signs seemed to point to gigantic balls, mostly of molten iron: the Sun, after all, must be made of the same stuff as the Earth? Except for the awkward fact that the Sun emits prodigious amounts of energy, while the Earth produces hardly any at all, by comparison.

Cecilia Payne was a firm believer in the power of objective experimentation. While a schoolgirl in the early twentieth century, she conducted a controlled experiment on the power of prayer by dividing her exams into two groups, one for which she prayed and the other for which she did not. It turned out that un-prayed for exams yielded the better results.

At Cambridge, Ernest Rutherford blatantly harassed her by encouraging his students to mock the only woman in the class. That did not put her off though; more likely strengthened her resolve. What did put her off was the fact that women were not allowed to conduct post-graduate work in England. She decamped to Harvard.

It had long been known that each element emits a unique set of light frequencies. But in the 150 million kilometres from the Sun to the Earth, light rays get mixed up with each other and with millions of other signals from all over the universe. What arrives on Earth is a jumble. Tease apart the jumble of light spectra and you find out what is in the Sun and the stars.

While modern AI can make short work of picking jumbles apart, in 1923, it was arduous, repetitive work that, nevertheless, demanded technical skill. So, it was done by computers: women scientists computing, day in, day out, dulling their often-first-rate scientific minds. They measured more than 100,000 spectral lines, without getting to try to make sense of any of them. Cecilia Payne was determined to avoid this fate.

Wedded to the Russian-born astrophysicist Sergei Gaposchkin, but not to the Sun-full-of-iron theory, when Cecilia Payne-Gaposchkin looked at those spectral lines, she saw hydrogen and helium instead. A hydrogen-helium Sun would not only challenge what was understood about how stars burn, but it would derail some distinguished careers and all the power and prestige that went with them.

Harvard might have been (mostly) welcoming to women scientists, but it was not having any of this kind of challenge - regardless of the evidence supporting it - or the fact that theoretical physics being conducted in Europe also pointed toward hydrogen.

For her historic insight that helped advance our understanding of the universe, Cecilia Payne-Gaposchkin was abandoned by erstwhile supporters, denied further research grants by Henry Norris Russell, who controlled such things, while her thesis adviser Harlow Shapley, deprived her of access to new electronic equipment that might have helped advance her work. Courses she taught were not listed in the Harvard or Radcliffe catalogues and her salary was paid out of 'equipment expenses'. It was not until 1956 that she was given a professorship.

### **Mary Wallace, “Wally” Funk** *Big girls don't fly*

Cecilia Payne-Gaposchkin knew a lot about the universe beyond Earth's atmosphere. Wally Funk, another 'upstart woman' went there. Eventually.

While growing up in 1940s America, Wally Funk dreamed of flying, but, as a girl, was discouraged from studies that might lead to a career in aviation. Nevertheless, at 19, she managed to earn a pilot's licence and then completed a degree in secondary education at Oklahoma State University, drawn to that institution by its “Flying Aggies” programme. There she earned a number of aviation certificates as well as qualifying as a flight instructor and a ground instructor.

She might have realised part of her dream by becoming a professional aviator, but rather than flying, she mostly taught army officers to do so and did other grounded jobs, such as inspecting aircraft for their safety and, later, investigating aviation accidents. She was 29 when she qualified as a commercial pilot, but, like other, similarly qualified women, was turned away by three commercial airlines that were averse to women pilots.

With the development of the USA's space programme, Wally Funk naturally wanted to don an astronaut's suit and be blasted aloft at the tip of a giant rocket. This dream seemed to become possible when, at 21, she participated in the 1961 Mercury 13 'Women in Space' programme and gained the necessary qualifications to work as an astronaut, but the programme was cancelled before she could do so.

More frustration came in the late 1970s when NASA finally began accepting women astronauts, although qualified, she was turned down for not having an engineering degree or background as a test pilot: exactly the qualifications denied her as a teenager!

Adding insult to injury, by the time women were piloting the space shuttle in the mid-1990s, she was considered too old.

Still, she was not giving up, and in 2012 paid her deposit to be one of the first to fly into space with Virgin Galactic, and in July 2020, Blue Origin announced that she would be on the first of its New Shepard flights into space.

Wally Funk spent her life setting records for women in aviation and space flight. Most recently, at the age of 92, she became the oldest person in space. She will also have been the first person to rate the space experiences offered by Virgin

Galactic and Blue Origin and tell us which is the better value for money. Her opinion should count.

## **Rachel Carson**

### *Speaking truth to power*

Most earthly animals know better than to fowl their nests. Not us. In fact, many of us became aware of the mess we weremaking of our home only when Rachel Carson ruffled some gilded feathers with her publication of *Silent Spring* in 1961, which arguably helped launch the environmental movement. However, she had been hard at work long before that.

Although her first work was in marine biology, notably her 1955 trilogy, 'The Edge of the Sea', she had worried about synthetic pesticide over-use, since many of them were developed in the mid-1940s as part of military programmes.

While not the first to raise concerns about the dangers of widespread pesticide over-use, her scientific knowledge and gift for writing meant *Silent Spring* reached a wide readership and generated popular support for legal action to stop aerial spraying of DDT, as well as subsequent injunctions to prevent future environmental damage.

*Silent Spring* drew on an impressive range of evidence and helped connect a sizeable community of scientists who were documenting not only specific examples of environmental damage caused by DDT spraying, but also the physiological and environmental effects of other synthetic pesticides. Government scientists and a group of biodynamic agriculturists advised by Dr Ehrenfried Pfeiffer, among other groups, helped her use official data and gather hundreds of individual incidents of human illness and ecological damage caused by pesticides.

The cruel irony is that, while completing the drafts of two chapters devoted to cancer, she discovered cysts that necessitated a mastectomy and turned out to be terminal. Doubly cruel as it was, Carson felt obliged to hide her cancer to avoid accusations that her work lacked credibility, being motivated by her own health issues.

Predictably, the chemicals industry, among others, fought back and many public officials instinctively sided with them against her. Among other things, they misrepresented the book's main argument, that, far from an outright ban, Carson's point was that pesticides should be used discriminately. After all, no responsible person wants to ignore insect-borne diseases. She pointed out that over- and long-term use are counter-productive, as they lead target species to develop resistance and even become stronger, weakening ecosystems over time and opening the way for invasive species to do even more damage. Compounding this, the effects of pesticides are poorly understood and cannot be confined to target species.

Speaking truth to power can provoke some colourful reactions, such as from American Cyanamid biochemist Robert White-Stevens, who described Carson as "... a fanatic defender of the cult of the balance of nature"; while in a letter to President Dwight D. Eisenhower, US Secretary of Agriculture, Ezra Taft

Benson argued that because she was unmarried, despite being physically attractive, she was “probably a Communist”.

It is testimony to the power of Silent Spring and Rachel Carsons’ writing, that efforts to discredit and refute its arguments served only to promote it further.

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