SAMPLE

Famous Astronomers: Cecilia Payne

What Stars Are Made Of

Aira Astralis

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

In 1925 a twenty-five-year-old Englishwoman, working at the Harvard College Observatory on a fellowship intended to keep women students busy, wrote a doctoral thesis that answered one of astronomy's oldest questions: what are the stars made of. Her answer, that the stars are nearly all hydrogen and helium, was so far outside every expectation that she was persuaded to hedge it, and the world took four more years to agree with her. Her name was Cecilia Payne, later Payne-Gaposchkin, and her thesis is remembered today as the most brilliant ever written in astronomy. This book tells her story and her science: the person, the discovery, the obstacles, the long career that followed, and the way her result, once doubted, became the foundation of modern astrophysics.

Her story deserves telling on its own terms, and it divides naturally into two halves. The first half is the making of a scientist against the grain: a girl from Wendover in Buckinghamshire, a father dead by her fourth year, a scholarship education, a Cambridge that taught her physics but would not give her a degree because she was a woman, and a crossing to America in 1923 that turned an uncredentialed English student into the first person to earn a doctorate in astronomy at Radcliffe. The second half is the making of a science: the thesis itself, built on the Harvard plate archive and the new ionization theory of Meghnad Saha, that found the composition of the stars; the long years of underpaid research on variable stars beside her husband Sergei Gaposchkin; and the late-in-life recognition, the Harvard professorship she received in 1956 as the university's first woman full professor, the department chair, the prizes.

The chapters follow the discovery story first, then the science of the thesis in plain terms, the observational craft behind it, the context of the Harvard Observatory and the era's treatment of women scientists, the modern understanding of what she found, her later research and its legacy, the challenges she faced, the trivia of a life full of memorable lines, two chapters on the thesis and the person's voice, and the significance of it all. The book's subject is a person, and its method is biography; but its heart is a single result, printed in a 1925 monograph and doubted politely for a few years, that reads now like the first sentence of modern astrophysics: the universe is made of hydrogen.

The result at the center of that thesis deserves a plain sentence at the outset, because everything in this volume circles it. Payne compared the dark lines imprinted on starlight with the same lines produced in the laboratory, ran the comparison through the era's newest quantum physics, and concluded that

the stars are made overwhelmingly of hydrogen and helium, the two lightest elements, in proportions that the Earth could not imagine: hydrogen about a million times more abundant in the Sun than in the terrestrial rocks, a universe of the lightest stuff rather than the heavy stuff the Earth had led everyone to expect. The claim was so far outside the era's assumptions that the thesis's own concluding chapter, at the urging of a senior referee, carried a sentence describing the abnormal abundances as almost certainly spurious, and the sentence, which history would quietly overturn, is part of the story this book tells: the moment when the right answer arrived ahead of its welcome.

What this volume does with the story is simple, and the reader may as well have the map now. The chapters follow the making of the result: the English childhood that tilted toward mathematics, the Cambridge lectures that introduced her to the new physics, the crossing to America and the Harvard plate archive, the two years of analysis, the thesis, and the long career that followed it, half a century of variable stars, novae, teaching, and administration at the observatory that first took her in. The chapters also weigh the result: what it meant for stellar physics, what it means now, and why the woman who produced it spent decades as a technical assistant before the professorship arrived. The map's final feature is the one the reader should hold most gently: the story has been told many times as a parable, sometimes unfairly, and this volume's work is to keep the documentary record, the whole of it, ahead of the moral.

Chapter 1: The Discovery of Cecilia Payne

The discovery of Cecilia Payne is a story about a scientist who discovered herself early, and then spent her life discovering the stars.

She was born on May 10, 1900, in Wendover, a market town in Buckinghamshire, England, into a family that valued learning and had little patience for convention. Her father, a London barrister and historian of the New World, died when she was four years old; her mother, an accomplished artist and musician, raised Cecilia and her siblings on limited means and strong encouragement, and the household's youngest child grew up with the double inheritance that her biographers note: an appetite for every subject and a stubbornness about her own path. School showed the pattern early. A scholarship carried her to St Paul's Girls' School in London, where she learned languages and mathematics with equal speed, and where a new science building had just been endowed with the words that the girl reportedly memorized on the spot: that scientific knowledge was a debt the present owed to the future. She would spend a career repaying it.

The school years deserve one more detail, the era's texture. Her grammar-school years included a mathematics teacher who took her seriously, and a chemistry course that misfired, a story her recollections tell with humor: an early laboratory foray ended in a small explosion and a ban, and the headmistress's curriculum offered the girls a choice of subjects that made the sciences an obstacle course rather than a track. She survived the course anyway, the pattern of her education being the pattern of her career, talent finding its own supply lines, and the family's own account of her childhood, her siblings' recollections collected in the autobiography's companion volume, describes a girl who read everything, argued everything, and organized the other children's games around whatever she had just learned.

Cambridge came in 1919, by scholarship, to Newnham College, one of the two women's colleges, and her plan was botany, the era's polite science for a polite young woman. The plan lasted until a public lecture. In December 1919 Arthur Eddington, fresh from the eclipse expedition that had tested Einstein's theory of gravity, told a Cambridge audience about the bending of starlight and the new universe it implied; Cecilia Payne was in the hall, and by her own recollection she left with her life decided, a speaker's account of a small displacement of a star on a photographic plate having done what no classroom had yet done.

She completed her studies in botany, then arranged to stay for a further year reading physics under Eddington himself, in a class of a handful of students,

an apprenticeship in the era's most exciting science with one of its greatest practitioners, a chapter of her life she treasured permanently.

The physics year deserves its own paragraph, the apprenticeship's texture. Eddington's class, the small graduate circle she joined, worked through the era's frontier material, the thermodynamics and the radiation physics that the young theory of stellar structure required; her recollections credit Eddington with the treatment that mattered most, the assumption that she belonged, the questions asked of her as of any student, an experience she contrasted, decades later, with the rest of her Cambridge years. She also did computational work for him, the eclipse expedition's checking arithmetic among her remembered tasks, the small labors that taught the craft the theory was made of, and the apprenticeship's combination, the great physicist's material learned at the great physicist's elbow, is the part of her English education she used longest.

Cambridge also taught her the lesson that would define her crossing. She completed the natural sciences tripos with distinction in 1923, but the university did not grant degrees to women; the women's colleges existed, the examinations existed, the results were read out, and the degree itself did not follow, a wrong Cambridge did not right until 1948, decades after her class graduated into nothing. She was also, in the event, an ambitious physicist in a country with no obvious place for one: the professorships were closed, the careers were closing, and her prospects were, as she put it plainly, nil.

The exit came at the Royal Astronomical Society's 1922 gatherings in London, where Harlow Shapley, then directing the Harvard College Observatory, described the great American institution's work; she introduced herself, he encouraged her to come, and the exchange, small in the moment, became the hinge of her life.

The fellowship's own arrangement deserves its lines, the crossing's paperwork. The American route ran through Radcliffe, the women's college adjacent to Harvard, because Harvard itself did not admit women to its graduate school; the fellowship that brought her, and the doctorate she earned in 1925, were Radcliffe's, the degree's title page reading the women's college's name while the work was done at the men's observatory, the arrangement's absurdity its own commentary on the era. The absurdity had a use, though, the era's one honest doorway: the Radcliffe arrangement brought a handful of brilliant women into the Harvard scientific orbit, Payne the first in astronomy, and her doctorate, the first the college granted in the subject, made the doorway official, the small door the big discovery came through.

She sailed in 1923, on a Radcliffe College fellowship, to the Harvard College

Observatory in Cambridge, Massachusetts, where Shapley had begun building a graduate school around the world's greatest archive of stellar photographs. Her first sight of the observatory and its collection, she wrote later, was a revelation: the glass plates by the hundreds of thousands, the spectra of the stars by the decade, and behind them the workforce of women computers who had organized the sky itself. Within two years, in 1925, she had written and defended the thesis titled Stellar Atmospheres, her observational study of the high temperatures in the stars' reversing layers, earning the first doctorate in astronomy granted by Radcliffe, and launching, at twenty-five, the result this book exists to explain.

The discovery of Cecilia Payne, in the sense this chapter means, was her own: the person who wanted the stars at eight and the physics at nineteen, and who arranged, against every convention of her time and place, to be in the room where the universe was being decoded.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.