Female Darwin: It was a time when women were not awarded doctoral degrees in physics even given they qualified. Thus, a new department was created at Harvard, which granted the first Ph.D. degree in astronomy to Dr. Cecilia Payne, a woman. Her 1925 Ph.D. thesis changed the face of astrophysics and our understanding of the origin of the universe. It is notably referenced as the astrophysical Origin of the Universe equivalent of Darwin's Origin of the Species.

Payne's thesis demonstrated for the first time how to "read" the surface temperature of any star from its spectrum that she documented was in fact a sequence of decreasing temperatures, temperatures she was able to calculate and identify. Her thesis laid the foundation to understand the chemical composition of the stars, and became the most powerful analytical tool in stellar astrophysics. Here is her story.

Cecilia Helena Payne (1900–1979) born in Wendover, England, was one of three children raised by her single mother after her father died when she was four. She attended St. Paul's Girls' School and in 1919 won a scholarship to Newnham College at Cambridge where she studied botany, physics, and chemistry. Her interest in astronomy came from a lecture by Arthur Eddington about his expedition to the island of Principe in the Gulf of Guinea to observe and photograph daytime stars during a solar eclipse.

At a subsequent Cambridge event with Professor Eddington, she told him she wanted to be an astronomer. He suggested a number of books for her to read but she had already read them. He then invited her to use the Observatory's library with access to all the latest astronomical journals. This simple gesture opened the world of astronomical research to her.

Upon completing her course requirements, however, she was not granted a college degree because Cambridge did not grant degrees to women, irrespective that she was an elected member of the Royal Astronomical Society while still a student. (Cambridge would not grant degrees to women until 1948).

Without higher academic education, Payne realized her only career option as a female in the U.K would be as a teacher, thus she sought opportunities to study in the United States. Harlow Shapley, Director of the Harvard College Observatory, had just begun a graduate fellowship program in astronomy to encourage women to study at Harvard. The first female student on the fellowship was Adelaide Ames in 1922 and the second was Payne in 1923.

Shapley persuaded Payne to write a doctoral dissertation. Her thesis was "Stellar Atmospheres, A Contribution to the Observational Study of High Temperature in the Reversing Layers of Stars." Renown astronomers Otto Struve and Velta Zeberg called it "undoubtedly the most brilliant Ph.D. thesis ever written in astronomy." But it was radical.

It documented that the sun was predominately composed of 98% hydrogen and helium

and that only 2% of its mass came from the other chemical elements, such as iron, oxygen and silicon. Thus, the sun was chemically different in composition from the earth. This was contrary to the accepted theory of the time that composition of the earth and the sun was very similar.

When Payne showed an early draft of her thesis to Shapely, he was so stunned by the result that he sent it to a male colleague for a second opinion. Despite no error could be found in Payne's calculations, the two men concurred that her findings were not valid.

Albeit their concurrence contradicted what Payne knew, but to protect her reputation and position in the male dominated bureaucratic field of astronomy, she inserted a conciliatory clause stating that “perhaps” the results were "probably not real.”

Her thesis received extensive scrutiny. Astronomers, such as, Princeton’s Henry Norris Russell dissuaded her from publishing her conclusion. Russell wrote to her, "It is clearly impossible that hydrogen should be a million times more abundant than the metals.” But within four years her work would be proven to be correct by none other than Russell himself.

Russell had subsequently derived Payne’s findings by different means and discovered she was right. He published his findings, and although he briefly acknowledged her work in his paper, Russell was often given, and took, credit for the discovery.

Still, the chair of Harvard's physics department would not accept a female graduate student, or her thesis, even after it had been proved correct and accepted, thus the faculty committee awarded her Ph.D. by effectively creating a department of astronomy. Thus in 1925, Payne became the first person to earn a Ph.D. in astronomy from Radcliffe College (now part of Harvard).

After her doctorate, Dr. Payne lectured in the astronomy department. But her lectures were not listed in the course catalogue. She directed graduate research, but without status. She had no research leaves, and her small salary was categorized by the department under 'equipment.' Despite gender discrimination (not yet openly acknowledged) Payne survived and flourished. 'It was a case,' she said, 'not of survival of the fittest, but of the most doggedly persistent.’

In 1931, Payne became an American citizen. On a tour through Europe in 1933, she met Russian-born astrophysicist Sergei I. Gaposchkin in Nazi Germany while in Berlin. She helped him get a visa to the United States, they married in 1934, and had three children. Throughout her life, now a wife and mother, Payne-Gaposchkins remained scientifically active spending her entire scientific career at Harvard.

At Harvard, however, she received little pay, had a low status and held no official position. She served only as technical assistant to Shapely from 1927-1938, when she was given the title of astronomer. When Donald Menzel took over as Director in 1954 she became the first woman promoted to full-professor from within the faculty at Harvard. Later, with her appointment as Chair of the Department of Astronomy, she became first woman to receive tenure, and the first woman to head a department at Harvard.

Payne continued to study stars of high luminosity in order to understand the structure of the Milky Way. With her husband, she studied variable stars and laid the basis for all subsequent work on them as indicators of galactic structure (origin). Their work later extended to the Magellanic Clouds adding a further 2,000,000 observational data used to determine the paths and origin of stellar evolution, described in her books, *Variable Stars and Galactic Structure* (1954) and *The Galactic Novae* (1957).

Payne's career marked a turning point of more opportunities in astronomy to women. The trail she blazed into the largely male-dominated scientific community was an inspiration to many. Albeit notable gender achievements had been made earlier in the century, with Payne's Ph.D., women entered the 'mainstream.'

Payne-Gaposchkin retired from active teaching in 1966 and subsequently was appointed Emeritus Professor of Harvard. She continued her research as a member of staff at the Smithsonian Astrophysical Observatory. The asteroid 2039 Payne-Gaposchkin is named after her.

Sources: http://en.wikipedia.org/wiki/Sun
http://en.wikipedia.org/wiki/Cecilia_Payne-Gaposchkin
http://www.uuworld.org/2003/01/lookingback.html
http://apps.carleton.edu/campus/observatory/research/cindystudents/1997sp/women/payne/
http://www.sheisanastronomer.org/index.php/history/cecilia-payne-gaposchkin
http://www.amnh.org/education/resources/rfl/web/essaybooks/cosmic/p_payne.html
http://www.theguardian.com/science/across-the-universe/2013/aug/23/cecilia-payne-gaposchkin-pants