CHAPTER 3
Henrietta's Law

During the first circumnavigation of the Earth, Ferdinand Magellan's crew relied on "certain shining white clouds" to find its way. There is no South Star to navigate by down under but the Nubecula Major and Nubecula Minor—the big and little clouds, as Magellan called them— helped one maintain a steady course. Invisible in most of the Northern Hemisphere, these impressive formations came into view as the fleet reached the latitude of what is now Brazil.

Magnified by telescopes, the pair of luminous hazes dazzled the mind. "In no other portion of the heavens are so many nebulous and stellar masses thronged together in an equally small space," wrote the astronomer John Herschel after observing them from the Cape of Good Hope in 1834. It was as though two pieces of the Milky Way had broken off and drifted. But that begged the question: Were these separate and distant galaxies or something smaller and nearby, suburbs of the Milky Way?

There was no reason to hope that the answer would be found in the images of the Magellanic Clouds that had been photographed at Harvard's station in Arequipa, Peru. Miss Leavitt was charged with nothing more than examining the "plates for variable stars. Each time she spotted one, she would scrutinize it with a magnifying eyepiece, determine its coordinates on the photographic plate, and carefully compute its change in magnitude by comparing it with other stars.

While she worked she might have remembered a story her father once told about Herschel himself. Speaking at an annual meeting of the American Missionary Association, Reverend Leavitt described how astronomers throughout Europe had greeted their colleague's great discoveries with disbelief: "Men said to him, in angry letters, 'We do not see what you see.' " Herschel, Reverend Leavitt continued, was ready with a response: "Perhaps you do not take the care in your observations that I do.... [W]hen I observe on a winter night I place my glass on the lawn at Greenwich, and let it stand there until the instrument comes to be of the temperature of the air." Moreover, the reverend said, Herschel ensured that his own body temperature would not affect the observations. " 'Oftentimes,' he said, 'I have been out in the winter air for two hours before I would open my glass, because I must come to be of the same temperature as the instrument itself.' "

Reverend Leavitt found a rather oblique spiritual message in the story, something about how a preacher must be of the same spiritual "temperature" as his "instrument" (God's word), and of the Bible and the heavens as well. Herschel's words might serve better as advice to a young astronomer: for all the excitement of discovering a new star or nebula, a good scientist was ultimately one who took care to consider the minutest of details, weighing each tiny component that made up an observation.

Henrietta apparently found such meticulous work satisfying enough that she amended her original plan to take her work back to Wisconsin. After a voyage to the British Isles in the summer of 1903 on the H.M.S. Ivernia, she took a quick train trip to Beloit to prepare for her relocation to Cambridge as a permanent member of the observatory staff.

Her decision paid off. One spring day in 1904 she was comparing plates of the Small Magellanic Cloud, taken at different times, when she noticed in the stellar spray several dots that had swelled and then receded in size. Variables. Her interest piqued, she examined other images, finding dozens more.

That fall sixteen more plates of this nebula were served up by the astronomers at Arequipa and shipped north to Boston, arriving at the observatory in January. When Miss Leavitt began scrutinizing these new photographs, variables popped up one after another —"an extraordinary number," she later wrote. The results, published in the observatory's regular circulars, made an immediate impression.

"What a variable-star 'fiend' Miss Leavitt is," a Princeton astronomer wrote to Pickering. "One can't keep up with the roll of the new discoveries." Even the newspapers took notice. A column of flippant news briefs in the Washington Post noted, tongue in cheek: "Henrietta S. Leavitt, of the Harvard Observatory, has discovered twenty-five new variable stars. Her record almost equals Frohman's." (Charles Frohman was a powerful theatrical producer and booking agent.)"

Day after day, she quantified the specks of pulsing starlight, filling in column after column of numbers. If there was anything noteworthy or unusual about a variable she would add a comment. The star with Harvard Number 1354 was "the northern star of a close pair, in a group of five." Number 1391 was "the southern star in a line of three." Number 1509 "appears to be at the centre of an extremely small, faint cluster."

Each star was an individual. Before long, she had discovered and cataloged hundreds of them in the two Magellanic Clouds, some of which flared no brighter than the fifteenth magnitude—thousands of times dimmer than the faintest stars she might have seen on a particularly clear night in the New England countryside.

She was boarding with Uncle Erasmus in a large Italianate villa (now part of the Longy School of Music) recently built for him on Garden Street. The house was just a short walk from Observatory Hill, where, for the next few years, she continued her research. Piece by piece, her results appeared in brief progress reports sometimes given to Pickering or Bailey to read in her absence at the December meetings of the Astronomical and Astrophysical Society of America, when she would be home in Beloit for Christmas. By 1908, six years after she had resumed her work, she published a full account, "1777 Variables in the Magellanic Clouds," in the Annals of the Astronomical Observatory of Harvard College. Twenty-one pages in length, the paper included two plates and fifteen pages of tables.

The sheer number of variables was surprising enough. But a reader with the patience to make it to the end of the paper would have found something even more remarkable. Almost as an afterthought, she had singled out sixteen of the stars, arranging them in a separate list showing both their periods and their magnitudes. "It is worthy of notice," she observed, that "the brighter variables have the longer periods."

In light of what astronomers know now, this is an understatement as magnificent as the one Watson and Crick made at the end of their famous "1953 paper on the double-helical structure of DNA: "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying method for the genetic material." This when they were telling their friends that they had discovered the secret of life.

Miss Leavitt was not being coy. She just didn't want to over-interpret her data. Since the variables were all in the Magellanic Clouds, they must be roughly the same distance from Earth. If the correlation she glimpsed held true, you could judge a star's true brightness from the rhythm of its beat. Then you could compare that with its apparent brightness and estimate how far it was. This was too profound a conclusion to hang on just sixteen stars. More measurements would have to be made.

That wasn't to happen anytime soon. The same year her results were published, Henrietta fell ill. On December 20, she wrote to Pickering from a Boston hospital, where she had been confined for the past week, thanking him for "the beautiful pink roses" and "for the kind thought so beautifully expressed. It means much at a time like this to be made to realize that one is remembered by one's friends."

To convalesce, she returned to Wisconsin to stay with her parents and two unmarried brothers, George, now a missionary, and Darwin, another clergyman. After resting through the next spring and summer, she planned to resume work in the fall. But in September she reported to Pickering that a "slight illness" contracted after a visit to a lake near Beloit had "proved unexpectedly obstinate, and I cannot tell when I shall be able to get away."

In October, after she had been absent for close to a year, Pickering wrote to inquire whether she would like him to send her some work. By early December, when she had not responded, he asked again, this time letting a glint of impatience show. "My dear Miss Leavitt," he began. "It is with much regret that I hear of your continued illness. I hope you will not undertake work here until you can safely do so. It may however relieve your mind if we can dispose of two or three questions…."

First he asked if she would send a letter at the beginning of each month stating whether she would be returning any time soon. Then he proposed that she issue a brief report (a so called Harvard College Observatory Circular) describing the preliminary results of another study she had been engaged in, the North Polar Sequence, a Herculean effort to measure, more accurately than ever before, the magnitudes of ninety-six stars near Polaris. This was one of Pickering's pet projects, of a higher priority to him than her study of variables. He hoped the North Polar Sequence would become the gold standard for gauging the brightness of stars throughout the sky.

She replied three days later, apologizing for being too weak to answer his earlier letter. "I thank you for expressing the desire that I wait for complete recovery before returning to Cambridge; it would make it even harder for me to be idle than it now is, if pressure were brought from without, especially from you. The thought of uncompleted work, particularly of the Standard Magnitudes, is one I have had to avoid as much as possible, as it has had a bad effect nervously." If she was "just as anxious about her Magellanic variables, she didn't say.

She held out hope that her condition might improve enough for her to resume work after Christmas. "Not the least of my trial in being ill is the knowledge of the annoyance it causes you."

In mid-January, Pickering wrote again, opening with the now familiar greeting and lament. "My dear Miss Leavitt: It is with much regret that I hear that your illness will again require you to postpone your return to Cambridge. It occurs to me that, when you do return, you may be able to do much of your work in your room, and thus save yourself the walk to the Observatory."

In the meantime she had told Mrs. Fleming that she was ready to work from Beloit, and Pickering, emphasizing again the importance of the North Polar Sequence, described some photographs he planned to send her, including one from the Mount Wilson Observatory in California, where a new 60-inch telescope, the largest in existence, was recording stars of exceeding faintness. He outlined his thoughts on how she should proceed with her measurements. "What do you think of this plan and can you suggest any improvements in it? … I hope you will not let these matters trouble you, and that you will not undertake any of this work, except with the approval of your doctor."

A few weeks later she received a box from Cambridge packed with photographic plates, paper prints, ledgers, a wooden viewing frame, and a 1½-inch eyepiece, allowing her to get back to gauging magnitudes. She responded with assurances that she was "now strong enough to work for two or three hours a day, and am very glad indeed to have the means of employing the time to advantage." She hoped, as always, for an early return to Cambridge.

For the next three months, she continued her calculations, sending back detailed reports to Observatory Hill. Her health continued to improve but at a glacial pace both she and Pickering must have found exasperating. "It is a great pity that my latest attempt to fix a time for returning to Cambridge should have failed like the others," she wrote to him in April, almost a year and a half since her absence began. This time, she assured him, her return really was imminent. "My physician has not yet given his consent to my departure, wishing to be assured of the soundness of my recovery. I now expect to receive my dismissal from him any day and to be in a position to make definite plans for resuming work."

By May 14, 1910, she was finally back in Cambridge, or was at least on her way. Her name and that of her colleague Annie Cannon appear on a list of observatory employees requesting tickets to the annual Harvard Class Day commencement ceremonies.

Her homecoming was short-lived. The following March her research was interrupted again when her father died, leaving his widow a modest estate that after probate costs and the settlement of debts was valued at just over $9,000. (He had kept the house on Warland Street, where Henrietta had been a girl, and owned a small amount of stock in a copper mining company that his brother Erasmus consulted for.) After thanking her colleagues for sending flowers, Henrietta departed for Beloit to console her mother.

When she had not returned by June, Pickering sent her a box with seventy photographic plates and other material for the North Polar Sequence, but she wasn't able to concentrate on the work for long. Ten days later she wrote to inform him that she and her mother were departing "rather unexpectedly" to stay with some in-laws in Des Moines. She offered no explanation.

She took the plates to the Beloit College library for safekeeping. "It is a new, fire-proof building," she assured him, "and is to be open all summer. The plates are on a strong shelf in a corner of the librarian's private office, and are labeled with a request that no one shall touch them. Orders to that effect have been given to the janitor....It will be a disappointment to lose nearly a month in my work on the plates, but there will be a good deal of work with the papers I shall take with me."

Her research wasn't entirely neglected. She even found time for her variable stars, sending a report for Pickering to read at a conference in Ottawa. After several more delays and apologetic letters, she returned that fall to her uncle's house on Garden Street.

Finally given the luxury of a long stretch of uninterrupted time, she turned back to the strange matter of the Magellanic variables, plotting twenty-five of them on a graph with their brightness on one axis and their period on the other. Her results were published in 1912 in a Harvard Circular under the name of Edward Pickering: "The following statement regarding the periods of 25 variable stars in the Small Magellanic Cloud has been prepared by Miss Leavitt."

The pattern now seemed clearer than ever. The stars lined up so neatly that she was moved almost to exclamation: "A remarkable relation between the brightness of these variables and the length of their periods will be noticed." The brighter the star, the slower it blinked. Why she didn't know, and for now it didn't matter. "Since the variables are probably at nearly the same distance from the Earth their periods are apparently associated with their actual emission of light."

In other words, you could determine how bright they really were. Without leaving Earth, you could count the beats of a star's rhythm, then use this to calculate its intrinsic magnitude. Compare that with its apparent magnitude and you would have its distance.

The universe had provided, for the especially keen observer, a hint of its grandeur. Imagine that you are standing on a back porch at night looking out over a dark field. Somewhere on the far edge is a mysterious array of electric lights. Some are brighter, some fainter, but since you don't know how bright they really are, you can't tell whether they are ten yards or ten miles away.

Now suppose that the lights are blinking, and that it has been decreed by some international authority that bulbs be manufactured so that they flash according to their brightness. Fifty-watt bulbs blink faster than 100-watt bulbs. If two of the beacons are pulsing at the same frequency, you know they are equally bright. So if one appears, say, four times dimmer, it has to be farther away.

To be precise, it is two times farther. Light traveling through space spreads and diminishes according to the inverse square law. Square the difference in distance and you get the difference in brightness. All other things being equal (which they never quite are), a light that is nine times dimmer than another must be three times farther away.

Although Miss Leavitt didn't use the term in her paper, the variables with this remarkable property are called Cepheids, for the first was discovered, in 1784, in the constellation Cepheus by an amateur English astronomer named John Goodricke. (He and Henrietta had more than astronomy in common: Goodricke was deaf and she was steadily becoming so.) The new law linking period and brightness would become known throughout astronomy as the Cepheid yardstick, a way to measure through great stretches of space.

There was just one problem: her Cepheids revealed only relative distances. You could say with some confidence that one star was twice as far away as another, and three times farther than another. But were they one, two, and three light-years from earth, or twenty, forty, and sixty? There was no way to know. To turn the ratios into actual distances, someone needed to discover how far the closest of the stars is from Earth.

For now, Miss Leavitt's new yardstick was one without numbers. The next step would be to calibrate it.

Excerpt From: George Johnson. "Miss Leavitt's Stars: The Untold Story of the Woman Who Discovered How to Measure the Universe (Great Discoveries)." Apple Books. https://itunes.apple.com/us/book/miss-leavitts-stars-untold-story-woman-who-discovered/id649229822?mt=11